

BRIDGES OF CALCUTTA AND ITS SURROUNDINGS

BY

S. CHATTERJEE,

B.Sc. (Cal.), B. E. (Civil), M. A. Sc. (Toronto), M. I. E. (Ind.), M. Mech. E. A., M. A. S., Etc.

Chief Engineer, Howrah Improvement Trust

Publishers :

The Technical Journals of India Private Ltd.

24, Brabourne Road, Calcutta I.

Price Rs. 4/-

CONTENTS

	<i>Page</i>
Foreword	V
Introduction	VII
Chapter I	
A case for a Second Howrah Bridge	I
Chapter II	
Classification of Bridges	12
Chapter III	
Major bridges of Calcutta and its surroundings	20
Chapter IV	
• Bridges across Circular Canal	28
Chapter V	
• Bridges across Tolly's Nullah and within Lake area	39
Chapter VI	
• Bridges within Port area and across Boat Canal, and Railway Bridges ..	50
Chapter VII	
• Bridges within Greater Howrah	60

BRIDGES OF CALCUTTA AND ITS SURROUNDINGS

BY

S. CHATTERJEE,

B.Sc. (Cal.), B. E. (Civil), M. A. Sc. (Toronto), M. I. E. (Ind.), M. Mech. E. A., M. A. S., Etc.

Chief Engineer, Howrah Improvement Trust

Publishers :

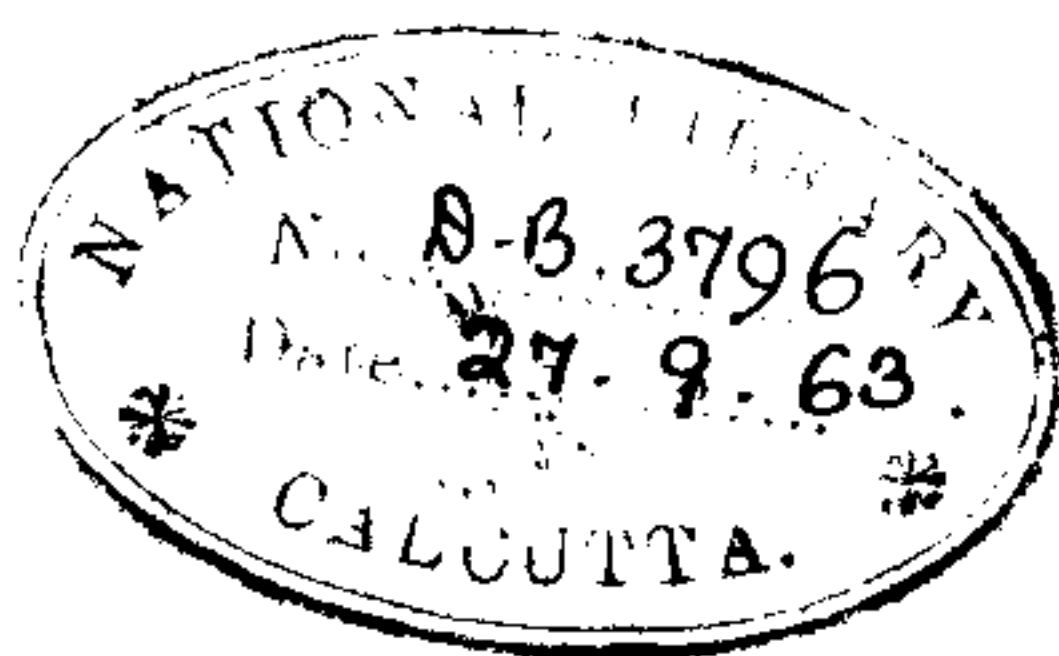
The Technical Journals of India Private Ltd.

24, Brabourne Road, Calcutta I.

Price Rs. 4/-

National Library. Calcutta,
Delivery of Books Act, 1954

22 APR 1963



CONTENTS

	<i>Page</i>
Foreword	V
Introduction	VII
Chapter I	
A case for a Second Howrah Bridge	I
Chapter II	
Classification of Bridges	12
Chapter III	
Major bridges of Calcutta and its surroundings	20
Chapter IV	
• Bridges across Circular Canal	28
Chapter V	
• Bridges across Tolly's Nullah and within Lake area	39
Chapter VI	
• Bridges within Port area and across Boat Canal, and Railway Bridges	50
Chapter VII	
• Bridges within Greater Howrah	60

out of print

Foreword

THE author has presented in this profusely illustrated book on the "Bridges of Calcutta and its Surroundings" in a non-technical way a highly technical branch of engineering and described all the aspects as briefly as possible.

The advent of the book is timely now that the second bridge across the river on which Calcutta stands will at last materialise as an essential item for the development of Calcutta Port from funds to be made available thro' the aid that is being given by the World Bank.

The *raison d'être* of this second bridge and its location have been explained by the author with clarity, based on the results and study of traffic data collected by the Howrah Improvement Trust (of which the author is the Chief Engineer).

11, Lower Rawdon Street
Calcutta
1st August, 1962

B. N. Dey
D. Sc. Engineering (Glasgow)
Former Chief Engineer, Calcutta Corporation

Introduction

THE city of Calcutta is not only the city of palaces but also the city of diverse problems. Under the shadows of palaces thrives a mushroom growth of horrible slums where nearly a quarter of the population of Calcutta, the premier city of India, live. There are calamitous deficiencies of civic amenities, an abnormal shortage of water supply, an inefficient sewerage system, a dislocated refuse removing arrangement which not only creates an ugly sight but the putrefaction of which fouls the surrounding atmosphere, an unplanned road system, chaotic traffic jam which creates pandemonium in Calcutta streets as the city fathers create a similar confusing situation within the four walls of the Corporation Hall in transacting their own civic affairs. It is the problem of bigness, the problem of enormity, the problem of monstrosity. Without a superman, a man with capability, strength and power, this Herculean task—the cleaning of the Augean stable cannot be achieved.

The extent of the problems of Calcutta is known. How to deal with them are also known. Technical know-how to translate these plans into achievement is known too. Technical personnel are not in short supply. Finance is not shy because of the Centre's promised contribution and planned provision for urban redevelopment. But politics is coming in the way and is creating unprecedented delay so as to make the problems more complicated. Thereby the cost of execution is becoming heavier with the passing of each day. Prof. Wolman, the leader of the team of experts from the World Health Organisation who were invited to explore the possibility of the formation of Metropolitan Water and Drainage Board to solve mainly the water, drainage and sewerage problems of Calcutta, aptly remarked, "You have money too in your pocket but your major deficiency is managerial".

One of the major problems of Calcutta is traffic. With the rapid increase in the number of vehicles—both fast and slow-moving, the problem has become more serious and acute. The problem has been further aggravated with the lack of parking spaces for different categories of vehicles in the down-town business area.

The original city of Calcutta was once almost surrounded by waterways—canals and rivers. But with the expansion of the city limits, the jurisdiction of civic activities has increased considerably. People began to live beyond the old city limits. To make suitable arrangement for their communication, several crossings of these waterways were considered imperative. Their importance is primarily and predominantly utilitarian and socio-economic.

Bridges are the expression of massive strength and power, a mode of express of the aesthetic taste of the community and city fathers, and an index of advancement and civilisation.

Whenever a new-comer enters a city, the monumental cloud-piercing magnificent structure draws his attention. The architectural effects through the imposition of decorative details and artistic embellishment, fine filigree and appropriate ornamentation are inherently beautiful in their functional harmony. It presents a saga of simplicity which impresses any observer with awe and admiration. Bridges are usually tall structures in the city as Golden Gate Bridge in San Francisco, Ambassador Bridge in Detroit, Howrah Bridge in Calcutta and so forth.

Bridges, as we all know, are costly structures. The total span remaining constant the economy in the cost of construction of bridges can only be achieved by reducing its width though the width of the existing approach roads may be greater. They are the bottlenecks in the traffic artery which need proper treatment for its improvement. There may be curiosity of the people to know the location of different bridges in different parts of the city and their types, shapes, sizes, approach inclinations and it is to satisfy some such inquisitiveness that this volume is presented.

The burning question of the day is an urge for a second bridge. The proposal of a second bridge across the river Hooghly (Bhagirathi) is based on the results and study of traffic data collected by the Howrah Improvement Trust on the present Howrah Bridge as well as Origin and Destination Survey within Howrah city as early as the end of 1959, and a pedestrian traffic survey in February, 1962. Its location at Shalimar has been very firmly established by a series of scientific and technical reasons as enumerated in the first chapter of this book.

During the critical time in between the date of completion of the second bridge and now, some immediate measure should be taken in the present bridge by controlling traffic movement to remove the peak hours and distribute the traffic load uniformly throughout the day and night. The police in charge of traffic are busy controlling that factor. If continuous flow can be maintained then the present bridge can take double the traffic load, for which modifications of the approaches are needed.

However, it is worthwhile to modify the present bridge structure slightly so as to introduce another tier over the sidewalks to carry pedestrians. The second storey for pedestrian use may be connected from Howrah Station. The present sidewalk can be used by slow-moving traffic. By this method, slow-moving traffic will be isolated and the speed of the fast-moving vehicles will increase.

Bridges of Calcutta and its Surroundings

CHAPTER I

A case for a Second Howrah Bridge

CALCUTTA, the biggest city and largest port of India, is not only a city of palaces but also a problem city as aptly described by our Prime Minister, Pandit Jawaharlal Nehru. It is due to undaunted efforts of engineers and builders, architects and administrators, industrialists and commercial magnets, financiers and investors that the city has grown so gigantic in size from a few clusters of huts of the rustic villages of Kalikata, Sutanuti, and Govindapur of the days of Job Charnock.

It is also a city of bridges. With the passing of time the city has expanded gradually to its present dimensions and incorporated many suburban areas far beyond the original city limits. In the early days of the British settlement in Kalikata, Sutanuti and Govindapur, a portion of the canal popularly known as Marhata Ditch was excavated in the eastern portion of the city so as to prevent the Maharastrian invaders from coming to the city proper for plundering. In order to facilitate communication in different directions of the city and for free traffic movement several bridges were constructed across the said canal. Subsequently, a new canal was also excavated which is now popularly known as New Cut Canal from which Krishnapur Canal branches off. They are also crossed by many bridges. In the southern portion of the city is the Dock area and the old course of the Bhagirathi, popularly known as Adi Ganga. A portion of it, now termed as Tolly's Nullah after the name of the excavator of later date, was dug to ease the obstructed flow of water from the Bhagirathi. In order to maintain the continuity of the road system, bridges were built across the water courses in the Dock area as also across Tolly's Nullah, and the artificial lake of Ballygunge. The railway system in and around Calcutta needed several bridges to be carried over the embankment. Of course, the small spans of railway bridges are of standard type and of standard length and of steel material.

The western suburb of Calcutta is Howrah which is practically a part and parcel of Greater Calcutta or Metropolitan Calcutta region. She is sometimes called the sad-faced sister of Calcutta, a pestilential town, a cooly town, but it is also known as the Sheffield of India. Howrah is the biggest market for piece-goods, mostly the products of cottage industries.

The city of Howrah (longitude 88°—21'—0" east and latitude 22°—35'—39" north) stands on the western bank of the river Bhagirathi (i.e., Hooghly according to foreigners during the last two centuries) which is considered as holy as Varanasi, i.e., Banaras, being on the western bank of the holy stream Bhagirathi. The city is bounded on the south and east by the river Bhagirathi; on the north by the jurisdiction of Bally Municipality and on the west by the mostly developed hinterland of the district. Here two main railway arteries (Eastern and South Eastern Railways) and two narrow gauge rail roads, i.e., Howrah-Amta and Howrah-Seakhala Light Railways of Messrs Martin and Co. Ltd., terminate. These two narrow gauge railway lines are known as Beam



Plate I.
The present Howrah Bridge : A view from the river.

Photo—B. Kar.

tramways. It is also the starting point of the Grand Trunk Road, the longest national highway of India. It covers an area of 7,285 acres, i.e., nearly 11.4 square miles. The topography of the land is almost flat and the soil is clayey. The city is full of hundreds of ponds and tanks, mostly insanitary. In spite of being so close to Calcutta, the city of Howrah was unable to keep pace with the gradually advancing standard of civic amenities of the premier city due to uncontrollable over-crowding, absence of a sewerage system, insanitary slums, insufficient water supply, inequitable distribution of population, frequent recurrence of epidemics of communicable diseases, like cholera, small-pox, etc., high incidence of crime, disturbing traffic congestion, unplanned drainage, inadequate recreational facilities, like parks and playgrounds, insufficient educational institutions and many other civic deficiencies. But, at the same time, Howrah is fortunate in having the river Bhagirathi, as the source of water supply as well as for receiving the discharge of the safe, clear and inodorous effluent from the sewage treatment plant and of the storm water drainage system. The river is a great asset but it is being turned into a liability by the discharge of trade wastes and partially treated sewage of foreshore industrial undertakings on both sides and more intensely by those situated on the Howrah side. It is the seat of the oldest engineering college of Bengal and is proud of having the largest botanical garden in India and of S.E. Asia. Howrah has a population of 5,14,090, according to the 1961 census and the rate of increase in population as indicated in Table I is very rapid.

It will be unfair if we fail to refer to bridges within Howrah. Though Howrah is connected with Calcutta through one of the famous cantilever bridges of the world, it is named after Howrah as the Howrah Bridge, not as the Calcutta Bridge. The latest traffic census undertaken by the Howrah Improvement Trust discloses an appalling state of affairs which is creating frequent traffic jams and thereby great inconvenience to the public over the bridge and on the approaches. The problem is not only vexing but also causes national loss by way of so many man-hours lost for so many conveyances and important men and women going to Howrah Station and moving out of it, unnecessary petrol consumption due to very slow movement of vehicles on the bridge and its approaches, mental agony due to vexation and annoyance and also due to undesirable hold-ups, etc. The present Howrah Bridge has already surpassed its designed traffic carrying capacity.

From the recent volumetric survey of vehicles of various categories, as indicated in Table II, conducted by the Howrah Improvement Trust at the western approach of Howrah Bridge, it has been observed that the peak flow of fast-moving vehicles from Calcutta to Howrah comes to 1,160 vehicles per hour from 7 to 8 p.m. and those going away from Howrah comes to 997 vehicles per hour specially from 6 to 7 p.m. Tables III and IV disclose hourly flow of different categories of vehicles, e.g., buses and vans, lorries, lorries with trailers, private cars and taxis, motor cycles and scooters, trams, cycles, rickshaws and cycle vans, animal drawn carts and hand carts, from Howrah to Calcutta and Calcutta to Howrah respectively whereas Table II discloses the peak flow of different categories of vehicles in different hours as well as the peak hourly flow for both fast and slow-moving vehicles.

From the above results it appears that three traffic lanes for fast-moving vehicles and two traffic lanes for slow-moving vehicles are necessary for each direction of traffic. So, the total width of the bridge necessary to accommodate ten traffic lanes—six for fast-moving and four for slow-moving vehicles—is 100 feet but the available width of the present bridge is 71 feet only, which is deficient by just over 40% of the peak flow. The problem will be aggravated with the increasing trend of manufacture of motor vehicles in India and due to import of more cars and other fast-moving vehicles from abroad in the near future.

Naturally, the construction of some other bridge or tunnel is felt urgently necessary to facilitate both pedestrian and vehicular traffic movement between Howrah and Calcutta. Now, where to locate the bridge or tunnel is the moot question for those who deal with the traffic problems.

It cannot be expected that the construction of another bridge across the river will solve the traffic problem either on the bridge or along its two approaches unless a part of the original sources of traffic volume and their destinations is suitably removed from Howrah Station and Burrabazar area. The bottlenecks of traffic congestion are the two approaches to the Howrah Bridge. The modification of bridge approaches at Howrah end by introducing suitable orientation of stands of both Howrah and Calcutta bound buses and by maintaining a unidirectional traffic stream both for slow and fast-moving vehicles will only shift the problem from Howrah side to Calcutta end.

The recent pedestrian traffic survey over the Howrah Bridge in the earlier part of 1962 discloses that the sidewalks provided are very inadequate. The results of pedestrian traffic survey are indicated in Table V.

It has been observed that the arrival and departure of trains of the South Eastern Railway get step-motherly treatment from the Eastern Railway authorities at Howrah Station for the movement of passengers. The concentration of traffic load at Howrah Station can be considerably reduced if the terminus of South Eastern Railway is shifted to Shalimar. The trains of the South Eastern Railway have to traverse a long distance from Santragachi Station to Howrah Station entailing a long time in transit because the distance between Santragachi and Howrah Station is nearly double of the distance between Santragachi and Shalimar. By this, distance and time may be reduced to 50% if the trains are diverted to Shalimar Station from Santragachi. If the second bridge is located in the north of the Shalimar Railway Yard close to the Shibpore Ghat at Howrah end, it will be necessary to bring the passengers of the South Eastern Railway to Shalimar Station wherefrom the passengers would go to their respective destinations at Howrah or on the other side of the river.

In the near future, it may be possible to export steel goods for earning foreign exchange. If the goods train can move directly into the port no doubt considerable time and money in transit and transshipment will be saved.

The proposed bridge should be cantilever type for the sake of economy, in order to avoid any pier on the bed of the river to avoid obstruction of flow and to span the typical width of the river Bhagirathi which is slightly over 1500 ft. The bridge may also be two storied. A single line railway track may be introduced in the lower storey to carry goods as well as passenger trains for the sake of economy but two tracks are preferable. The passenger train may terminate at a small station close to Fort William and be linked with the proposed circular railway on the other side of the river which is now under the consideration of the Government for removing traffic congestion. The goods train will then go directly into the Port area over the bridge. This type of cantilever bridge with railway line is already in existence in Canada. The famous Quebec Bridge is an example of such cantilever type. The underdeveloped area close to Shalimar and further west can be suitably used for industrial, commercial and residential purposes and for expansion of Shalimar Station. Close to the Railway Station, a commercial area may be developed. An industrial area close to the big industrial units, such as, D.V.C. Sub-station, State Electricity Sub-station, Guest Keen Williams, etc. is already in existence.

As a result of the recent internal Origin and Destination Survey conducted within the city of Howrah by the Howrah Improvement Trust by the method of recording "number-plates" at different traffic stations within the city, it has been observed that the number of trips of fast-moving vehicles coming to and going away from the Howrah Bridge approach on the Howrah side is 4,056 and 3,621 respectively (excluding those which are coming straight from Calcutta to Howrah Station and those going away from the Howrah Station to Calcutta). The count also excludes the buses, trams, semi-fast vehicles like cycles, cycle-vans and all other slow-moving vehicles. Out of the above number 1,580 come to Howrah Station from the Salkia and neighbouring areas and 1,520 go from Howrah Station to the Salkia and neighbouring areas. The remaining 2,476 vehicles go to Howrah Bridge approach side from Shalimar, Shibpore and Central

Howrah area and 2,101 vehicles come from Howrah Bridge approach side to the above area. It appears that the centre of gravity of the fast-moving traffic load leans towards Shalimar side in the present circumstances.

Many planners, thinkers, architects and engineers have put forward their ideas, views and suggestions in regard to the location of another bridge. They are in capsule as follows :

- (1) Across the river near Budge Budge, on Calcutta side, where the width of the river is narrow.
- (2) Near Salkia on Howrah side to connect Vivekananda Road on Calcutta side.
- (3) Near Sheoraphuli on the western side of the river.
- (4) Near Shalimar on Howrah side.

If we assume that private cars and motor cycles coming to Howrah and going away from there are estimated at 50% from northern and 50% from southern areas of Calcutta, then there is likelihood of 50% of the vehicles coming to Howrah from South Calcutta using any bridge or tunnel downstream of Howrah Bridge. From the traffic point of view, the location of the proposed bridge at Shalimar is more justified for the present than at a point opposite to Vivekananda Road. No doubt Vivekananda Road should be connected by suitable viaducts from the present Howrah Bridge almost parallel to the river as originally proposed and shown in the Port Commissioners Plan. If necessary, a third bridge may be constructed at some other suitable location after thorough volumetric and O-D surveys. Moreover, Vivekananda Road, as every user of that road is aware, is a very congested road from Strand Road to Chitpore Road. Its effective width has been reduced by the presence of a temple in the middle of the road and of crowds daily assembling before the Dravidian style Tulsi Temple of Bangurs and by series of standing lorries on both sides of the road.

After due consideration of the various aspects of the problem with regard to the suitability of the location of the bridge, which has been dealt with in detail, the location at Shalimar seems to be more logical and economical than any of those mentioned above for the following reasons :

- (i) it will not interfere with the movement of most of the ships,
- (ii) it will be upstream of Kidderpore and King George's Dock, i.e., the main Calcutta Port,
- (iii) it will be very close to Shalimar Goods Yard of South Eastern Railway which connects three major steel plants (TISCO of Tata, Rourkela and Bhilai plants of Hindustan Steel Ltd.) of India and her only copper factory.
- (iv) When Rupnarayan road bridge is completed, there will be more frequent movement of vehicular traffic. It is desirable that the vehicles should not pass through the heart of the congested city of Howrah but directly into Calcutta along the Andul Road, a branch from N.H. 6 and the proposed bridge approach road, i.e., along the periphery of the city,
- (v) If a central lift-span, as shown in Fig. 8, is provided the bridge approaches need not be high. The central suspension portion may be made as indicated in Dr. Waddel's proposal for the present Howrah Bridge sometime in 1920. Even in a bridge without movable parts the freeboard from high flood level will not require very long approaches.
- (vi) Spaces for two approaches both on Howrah side as well as on Calcutta side near Fort William are available without any dislocation of any existing public thoroughfare.
- (vii) There will be the least displacement and uprooting from one's hearth and home for the necessary land acquisition for the bridge approaches.
- (viii) A cross-over road is now being planned by the Road Department of Government of West Bengal across Shalimar Railway line which will be almost a straight approach to the proposed bridge site at Shalimar.
- (ix) People from South Calcutta can avail themselves of the bridge and of the fore-shore road to reach Howrah Station, the approach road of which needs little

modification from the south and can easily go to the Botanicals and up to National Highway No. 6 and further up.

- (x) It will be a close link between the docks and Howrah and its hinterland. It will help in the movement of food grains from ships to Howrah and other seaborne commodities to the railhead at Shalimar and Howrah.

The only disadvantage is that the proposed bridge will be close to the curve. As both the banks of the river are strengthened with necessary pitching and protection works, there is least chance of the river diverting its course. It is very desirable that the terminus of South Eastern Railway should be at Shalimar instead of it being located at Howrah so that passengers for South Eastern Railway will move to Shalimar through the second bridge. There is a great scope for the establishment of a commercial centre close to the bridge at Howrah end. The underdeveloped area of Howrah close to Andul Road will be soon developed.

TABLE I

Figures showing the variation of population during the last sixty years.

	Howrah City (area—11.4 sq miles)			Bally Town within Greater Howrah (3.06 sq miles)			Howrah district (568.2 sq miles)		
	Persons	Variation (number)	Percentage variation	Persons	Variation (number)	Percentage variation	Persons	Variation (number)	Percentage variation
01	1,57,594	—	—	18,662	—	—	8,50,514	—	—
11	1,79,006	+21,412	13.6	22,394	+3,732	20.0	9,43,502	+92,988	1.0
21	1,95,301	+16,295	9.1	23,209	+815	3.6	9,97,403	+53,901	0.5
31	2,24,873	+29,572	15.1	30,347	+7,138	30.6	10,98,867	+1,01,464	0.9
41	3,79,292	+1,54,419	68.7	50,397	+20,050	66.2	14,90,304	+3,91,437	3.3
51	4,33,630	+54,338	14.3	63,138	+12,741	25.3	16,11,373	+1,21,069	0.8
61	5,14,090	+80,460	18.5	1,02,285	+39,147	61.9	20,43,225	+4,31,852	2.1

According to Surveyor General of India.

TABLE II

Group No.	Description of vehicles	Calcutta-Howrah		Howrah-Calcutta		Average speed (M.P.H.)	Stream speed (M.P.H.)	Segregated lane capacity
		Peak flow (V.P.H.)	Hour (of the day)	Peak flow (V.P.H.)	Hour (of the day)			
Group I	Private cars and taxis	818	19-20	654	19-20	21.3	20	730 (Assuming car length of 15 ft.)
	Motor cycles and scooters	19	18-19	21	10-11	21.3		
	Group total	837		675				
Group II	Buses and vans	180	9-10	170	9-10	13.6	11	365 (Assuming lorry length of 40 ft.)
	Tram cars	73	9-10	75	9-10	13.6		
	Lorries and lorries with trailers	233	13-14	214	17-18	11.4		
	Group total	486		459				
Group I & II	Total of fast-moving vehicles	1,160	19-20	997	18-19		12	450*
	Cycles	364	17-18	181	9-10	6.8		
Group III	Rickshaws and cycle vans	258	19-20	231	19-20	3.6		300
	Animal drawn vehicles	34	19-20	38	7-8	2.3		
	Hand carts	319	11-12	253	13-14	2.7		
	Total of slow-moving vehicles	619	17-18	484	7-8	2.5		

TABLE III
Volumetric traffic survey—24 hours.
Howrah Bridge Approach West (Up i.e. towards Calcutta).

Dated—21.10.59.

Time in hours.	Buses and vans	Lorries	Lorries with trailers	Private cars and taxis	M. cycles and scooters	Tram cars	Total of fast- moving vehicles	Cycles	Rickshaws and cycle vans	Animal drawn vehicles	Hand carts	Total of slow- moving vehicles	Grand total
6-7	142	87	—	178	2	45	454	75	128	4	22	229	683
7-8	153	79	—	293	9	49	583	161	166	38	70	484	1,067
8-9	149	120	—	343	6	45	663	158	90	14	74	336	999
9-10	170	168	7	449	16	75	885	181	78	4	108	371	1,256
10-11	154	165	5	543	21	60	948	123	102	13	122	359	1,307
11-12	148	214	1	458	11	50	882	67	108	19	168	362	1,244
12-13	57	75	—	161	1	14	308	19	39	1	87	146	454
13-14	145	173	3	314	17	21	673	60	110	9	253	432	1,105
14-15	146	194	2	411	8	35	801	76	134	9	249	468	1,269
15-16	141	186	1	481	8	51	868	61	150	4	234	449	1,317
16-17	142	206	2	443	14	46	853	78	116	5	236	435	1,288
17-18	143	209	5	506	13	53	929	86	118	16	142	362	1,291
18-19	179	177	2	584	8	47	997	36	174	17	105	332	1,329
19-20	146	118	4	654	9	52	983	26	231	21	67	345	1,328
20-21	141	82	3	599	6	52	883	26	190	21	34	271	1,154
21-22	109	51	3	324	6	43	536	26	128	9	24	187	723
22-23	73	34	3	162	3	36	311	17	53	4	24	98	409
23-24	10	23	1	72	—	9	115	5	14	6	13	38	153
0-1	7	22	1	42	—	1	73	1	8	3	7	19	92
1-2	5	12	1	13	1	—	32	2	5	—	7	14	46
2-3	13	17	—	1	—	—	21	—	2	1	1	6	27
3-4	9	10	—	14	—	1	34	—	25	1	9	36	70
4-5	30	19	1	71	1	1	123	33	84	11	20	148	271
5-6	92	69	—	156	1	36	354	53	94	14	32	193	547
							13,309					6,120	19,429

TABLE IV
Volumetric Traffic Survey—24 hours.
Howrah Bridge Approach West (Down i.e. towards Howrah).

Date—21.10.59.

Time in hours	Buses and vans	Lorries	Lorries with trailers	Private cars and taxis	M. cycles and scooters	Tram cars	Total of fast- moving vehicles	Cycles	Rickshaws and cycle vans	Animal drawn vehicles	Hand carts	Total of slow- moving vehicles	Grand total	
6-7	108	24	4	220	3	46	405	41	129	2	69	241	646	
7-8	165	59	—	281	10	48	593	73	159	9	130	371	964	
8-9	146	78	1	395	11	41	672	57	136	29	119	341	1,013	
9-10	180	119	—	481	15	73	868	42	84	5	128	259	1,127	
10-11	197	146	6	475	12	67	903	57	122	14	178	371	1,274	
11-12	164	199	5	349	11	48	776	61	151	20	319	551	1,327	
*12-13	19	95	2	202	7	32	377	20	61	7	122	190	567	
13-14	136	227	6	338	7	24	738	53	109	4	180	346	1,084	
14-15	122	188	5	366	9	36	726	82	118	6	230	436	1,162	
15-16	151	195	2	456	9	53	866	75	133	6	203	417	1,283	
16-17	144	195	1	367	7	39	753	117	110	5	185	417	1,170	
17-18	140	156	4	434	18	56	808	364	119	20	116	619	1,427	
18-19	166	137	2	660	19	45	1,029	139	194	30	103	466	1,495	
19-20	146	127	—	818	9	60	1,160	94	258	34	76	462	1,622	
20-21	136	138	—	593	8	60	935	96	188	27	52	363	1,298	
21-22	131	130	—	368	7	44	680	67	111	6	25	219	899	
22-23	103	131	—	187	6	43	470	53	58	4	16	131	601	
23-24	27	79	—	96	1	4	207	16	20	2	11	49	256	
0-1	10	40	—	47	—	1	98	5	12	2	2	21	119	
1-2	5	20	1	16	1	—	43	3	10	2	5	20	63	
2-3	3	16	—	3	—	—	22	2	8	—	3	13	35	
3-4	5	9	—	16	—	1	31	11	7	1	12	31	62	
4-5	27	12	—	89	—	6	134	46	64	7	29	146	280	
5-6	57	15	—	111	1	39	223	37	105	5	60	207	430	
							13,517						6,687	20,204

Total—Up and Down—13,309
13,517

26,826 for fast-moving vehicles.

TABLE V (Part A)
Pedestrian traffic count for 16 hours from 6 a.m. to 10 p.m. on Howrah Bridge from 21st to 24th February 1962.
 Calcutta to Howrah

Time in hours	21. 2. 62.			22. 2. 62.			23. 2. 62.			24. 2. 62.		
	Calcutta to Howrah			Calcutta to Howrah			Calcutta to Howrah			Calcutta to Howrah		
	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total
6-7	850	560	1,410	750	150	900	660	210	870	650	280	930
7-8	1,000	710	1,710	1,100	650	1,750	830	680	1,510	1,070	440	1,510
8-9	990	700	1,690	850	640	1,490	900	610	1,510	1,030	560	1,590
9-10	1,330	870	2,200	1,170	720	1,890	1,200	700	1,900	1,270	690	1,960
10-11	1,930	750	2,680	1,948	1,930	3,878	2,230	1,000	3,230	1,930	730	2,660
11-12	1,830	610	2,440	2,070	1,500	3,570	2,060	1,000	3,060	1,710	1,070	2,780
12-13	1,580	840	2,420	1,840	1,510	3,350	3,060	820	3,880	1,670	920	2,590
13-14	1,460	720	2,180	1,370	1,360	2,730	1,620	660	2,280	2,650	1,570	4,220
14-15	1,840	670	2,510	1,460	860	2,320	1,770	770	2,540	4,460	2,320	6,780
15-16	2,450	860	3,310	1,860	1,040	2,900	2,330	1,000	3,330	4,430	2,090	6,520
16-17	2,930	970	3,900	2,670	1,500	4,170	2,790	1,120	3,910	4,450	1,890	6,340
17-18	7,290	2,000	9,290	7,300	2,000	9,300	9,310	2,900	12,210	5,150	2,000	7,150
18-19	6,740	2,370	9,110	5,870	4,610	10,480	8,230	2,540	10,770	3,500	1,940	5,440
19-20	4,440	3,000	7,440	4,650	2,440	7,090	4,880	1,860	6,740	2,000	1,300	3,300
20-21	3,110	3,000	6,110	2,950	1,870	4,820	4,400	1,860	6,260	2,000	1,270	3,270
21-22	1,620	2,820	4,440	2,310	1,220	3,530	2,240	1,690	3,930	1,750	700	2,450
	41,390	21,450	62,840	40,168	24,000	64,168	48,510	19,420	67,930	39,720	19,770	59,490

TABLE V (Part B)
Pedestrian traffic count for 16 hours from 6 a.m. to 10 p.m. on Howrah Bridge from 21.2.62 to 24.2.62.
Howrah to Calcutta

Time	21.2.62.			22.2.62.			23.2.62.			24.2.62.		
	Howrah to Calcutta			Howrah to Calcutta			Howrah to Calcutta			Howrah to Calcutta		
	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total	South Footpath	North Footpath	Total
6-7	1,140	850	1,990	1,450	750	2,200	950	910	1,860	970	630	1,600
7-8	1,930	1,110	3,040	1,890	1,120	3,010	1,870	1,380	3,250	1,740	1,060	2,800
8-9	3,160	1,400	4,560	2,850	1,340	4,190	3,200	1,320	4,590	3,580	1,690	5,270
9-10	6,130	3,450	9,580	6,270	3,530	9,800	8,110	2,940	11,050	4,330	3,750	8,080
10-11	5,870	2,140	8,010	3,610	1,772	5,382	4,060	2,300	6,360	2,150	2,400	4,550
11-12	3,040	1,290	4,330	1,770	1,004	2,774	1,970	1,060	3,030	1,320	1,374	2,694
12-13	1,700	930	2,630	1,850	772	2,622	2,430	782	3,212	1,260	1,020	2,280
13-14	2,050	1,230	3,280	2,440	892	3,332	3,490	1,130	4,620	620	1,010	1,630
14-15	1,690	1,130	2,820	1,060	1,180	2,240	1,490	1,020	2,510	1,760	1,820	3,580
15-16	2,160	1,270	3,430	1,820	980	2,800	1,980	1,290	3,270	1,800	1,450	3,250
16-17	1,790	1,190	2,980	1,360	1,420	2,780	1,640	1,310	2,950	1,860	1,150	3,010
17-18	1,650	1,850	3,500	1,900	1,420	3,320	2,430	2,040	4,470	2,000	1,090	3,090
18-19	2,056	1,050	3,106	1,570	1,280	2,850	1,670	1,460	3,130	2,120	1,200	3,320
19-20	1,975	750	2,725	1,560	800	2,360	1,040	630	1,670	1,480	586	2,066
20-21	1,064	390	1,454	1,070	584	1,654	1,060	670	1,730	1,476	382	1,858
21-22	538	320	858	604	553	1,157	710	296	1,006	507	603	1,110
	37,943	20,350	58,293	33,074	19,397	52,471	38,170	20,538	58,708	28,973	21,215	50,188

CHAPTER II

Classification of Bridges

Preliminary discussion with regard to the various types of bridges is necessary before indicating the types of bridges in Calcutta and its surroundings.

A. Depending on the position of the moving load in relation to the location of the tracks within or on the spanning structure, bridges may be divided into four classes :

- (1) Deck type—where the load passes over the deck.
- (2) Half-through type—where the rolling load moves half through the bridge structure.
- (3) Through type—where the rolling load passes completely within the bridge structure.
- (4) Suspended type—where the moving load is suspended from the main structure.

Of course, the deck type bridge is one of the cheapest types of bridges.

B. In relation to the manner of transferring the load to the foundation after proper investigation of the nature of the foundation rock or soil, bridges are classified as follows :

- (1) Simply supported single span or continuous beams and girders as well as framed structures where load is vertically transmitted to the foundation.
- (2) Arch type bridge—
 - (a) fixed arch.
 - (b) pin-jointed or hinged
 - (i) single pin, i.e., pin at the crown.
 - (ii) two pins, i.e., at two springing points of arch.
 - (iii) three pins, i.e., one at crown and two at springing points.
- (3) Cantilever bridge—
 - (a) simple cantilever,
 - (b) double cantilever,
 - (c) balanced cantilever.
- (4) Suspension bridge—
 - (a) with twisted wire cables,
 - (b) with chains of flat mild steel or alloy steel bars or links,
 - (c) with chains of square or road bars, now almost obsolete.
- (5) Combination of the above types.

C. With respect to the method of construction or method of joining of members, bridges are divided into the following classes :

- (1) Plate girder including heavy section rolled steel joists.
- (2) Riveted truss bridges.
- (3) Pin-jointed bridges.
- (4) Welded steel structure bridges.

D. Based on the types of construction materials, bridges may be classified in the following manner :

- (1) Timber bridges—where woods, logs, scantlings, bamboos, plywoods, etc. are used.
- (2) Brick-built bridges.
- (3) Stone-built bridges.
- (4) Cement concrete bridges.
- (5) Reinforced cement concrete bridges, now very popular material for bridge work.
- (6) Prestressed reinforced concrete bridges.

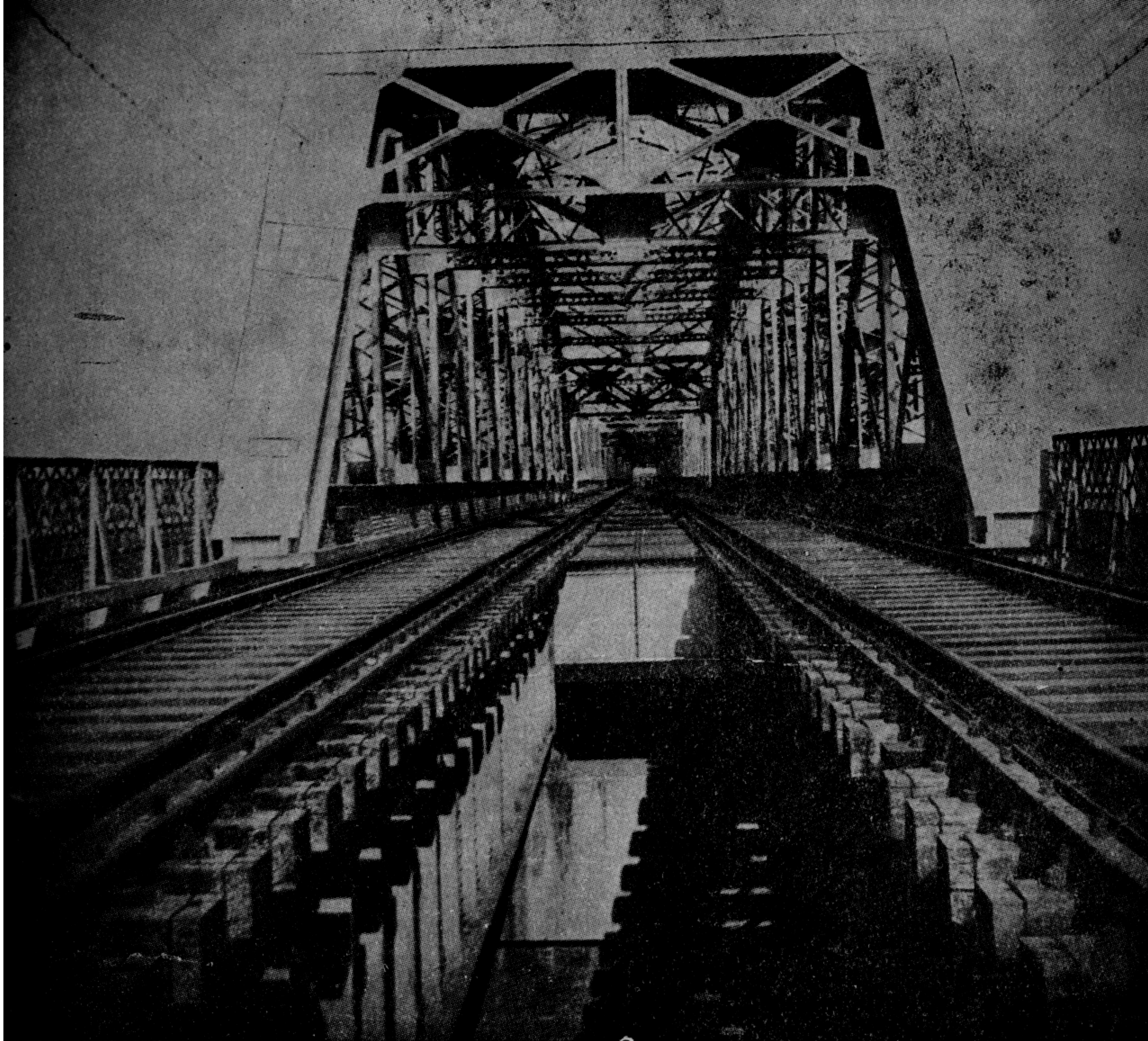


Plate 2.

Vivekananda Bridge: A view through the Bridge.

Photo -- B. Kar.

- (7) Post-stressed reinforced concrete bridges.
- (8) Mild steel bridges, which were very common in the past.
- (9) High tensile steel bridges, which are used under special circumstances.
- (10) Alloy steel bridges, specially of nickel steel.
- (11) Wrought iron bridges which are now almost obsolete.
- (12) Steel wire cable bridges.
- (13) Welded steel structure bridges, which are coming into the field for economy of steel materials.
- (14) Aluminium alloy bridges.
- (15) Cast iron bridges.

The famous cast iron bridge at Craig-Elachie in Scotland designed by Telford was an arch of 150 ft span with a rise of 20 feet consisting of four ribs, each one of which had two concentric arcs fastened together by diagonals.

Popular forms of reinforced concrete bridges are :

- (1) Deck slab bridges.
- (2) T-beam and slab bridges.
- (3) Bow-string girder bridges.
- (4) Arched type bridges—

(a) with cellular ribs,

(b) with ordinary ribs.

- (5) Balanced cantilever bridges.

In addition to the above main categories, there are a few more minor categories :

E. With reference to interspan relations like :

- (1) simply supported ;
- (2) continuous ;
- (3) one end fixed and the other end free ;
- (4) both ends fixed ;
- (5) cantilever.

F. With reference to the designation of function or purpose, e.g.,

- (1) Aqueduct ;
- (2) Viaduct ;
- (3) Road bridge ;
- (4) Railway bridge ;
- (5) Foot bridge, etc.

G. By the method of providing headroom or clearance for navigation ; as

- (1) fixed bridge ;
- (2) movable, in part or in whole ;
- (3) transportation type.

H. With reference to the storey the bridge may be single storeyed or multi-storeyed i.e., one meant for railways and the other for highway as in Allahabad.

One for slow-moving and the other for fast-moving traffic may be used.

There are a few miscellaneous varieties like (a) swing bridge, (b) vertical lift bridge, (c) bascule bridge, (d) pontoon bridge, (e) covered bridge, etc.

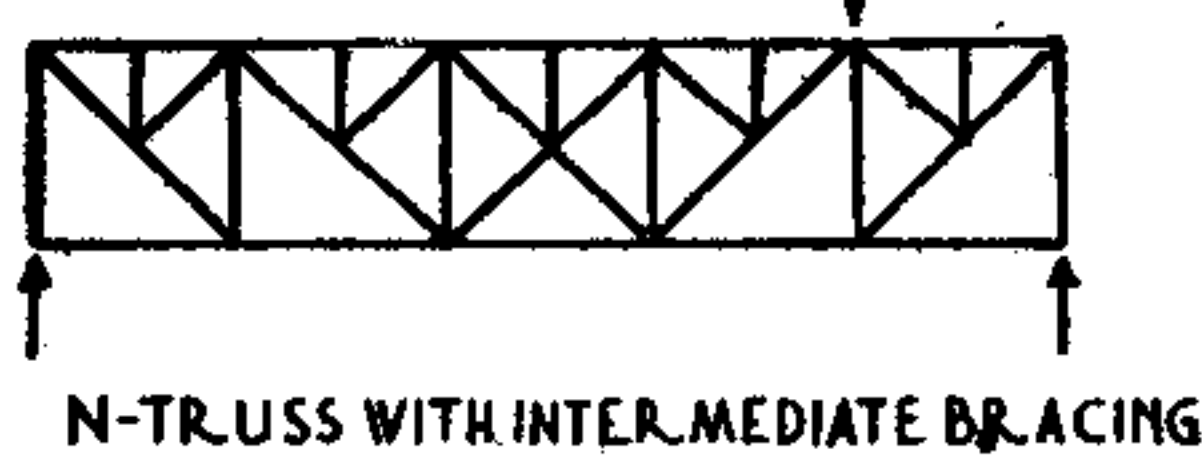
Different types of trusses are formed by the suitable arrangement of the constituting members in a truss. Most popular among the standard trussed structures is Latticed Girder. Then come the popular names like Whipple Truss, Howe Truss, Baltimore Truss, Pratt Truss or N-Type, the Warren Girder and K-type Truss and the latest one is Wichert Truss, a recent form of continuous trussed bridge.

A drawing showing the types of fabricated structures is shown in Figs. 1 and 2.

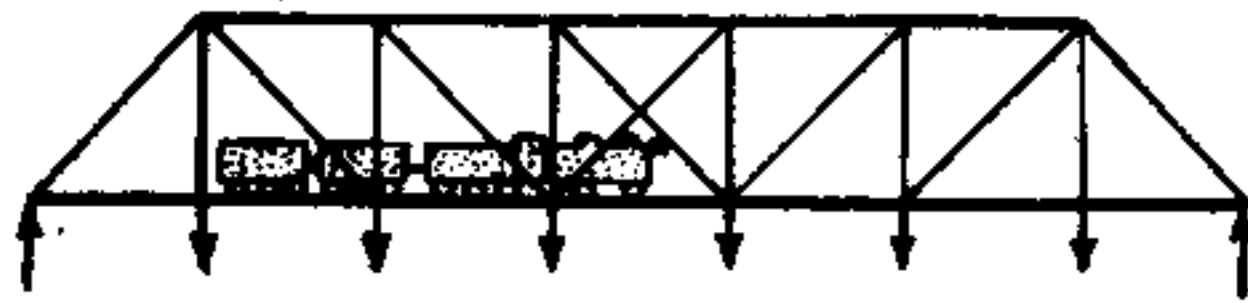
The longest span of double leaf bascules is in Canada. It was constructed for Canadian Pacific Railroad (CPR) bridging a span of 336 ft across the ship canal of Saulte Sainte Marie, Michigan.

The selection of the type of bridge in respect of the length of the span to be closed has already been experimented upon, the economical type evolved depending, of course, upon the geological feature of the locality. There is very little choice if the spans are fixed. It will not be out of place to mention that the total normal cost of the bridges is almost shared equally by superstructures and substructures, i.e. piers, abutments and foundation works.

Models of costly bridges are subjected to severe wind tunnel-tests so as to avoid devastating disaster due to erratic wind effect upon bridge structures when actually constructed at site.



THROUGH TYPE



DECK TYPE

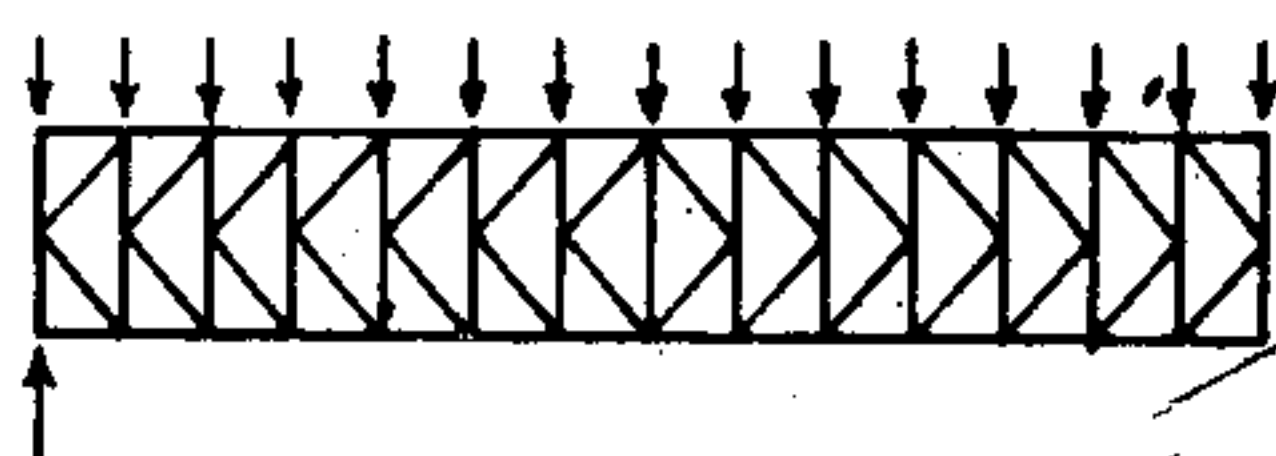
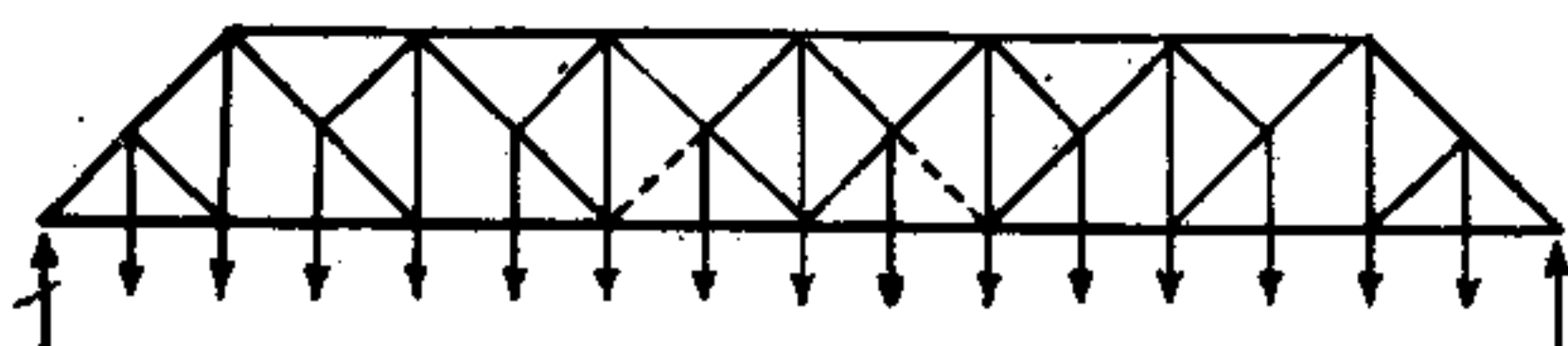
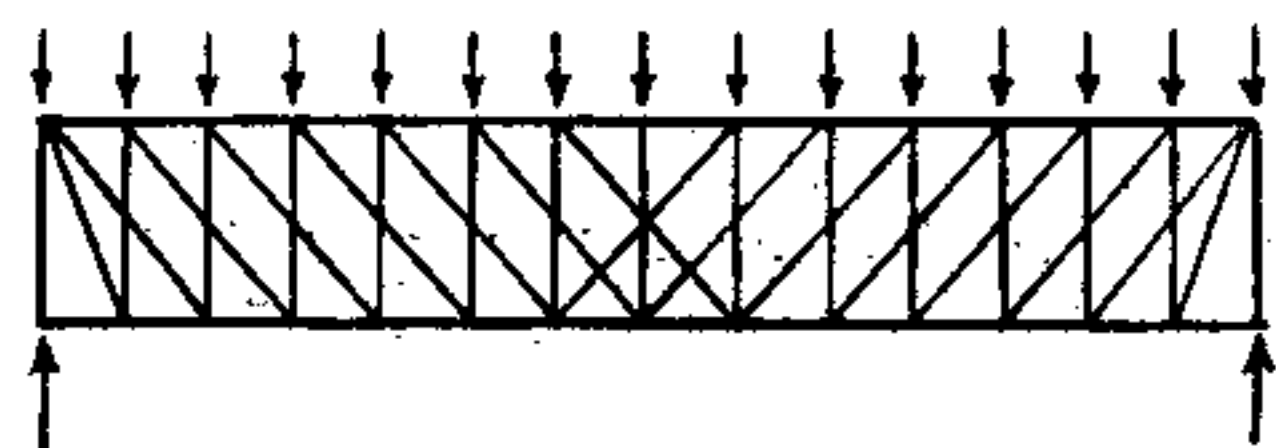
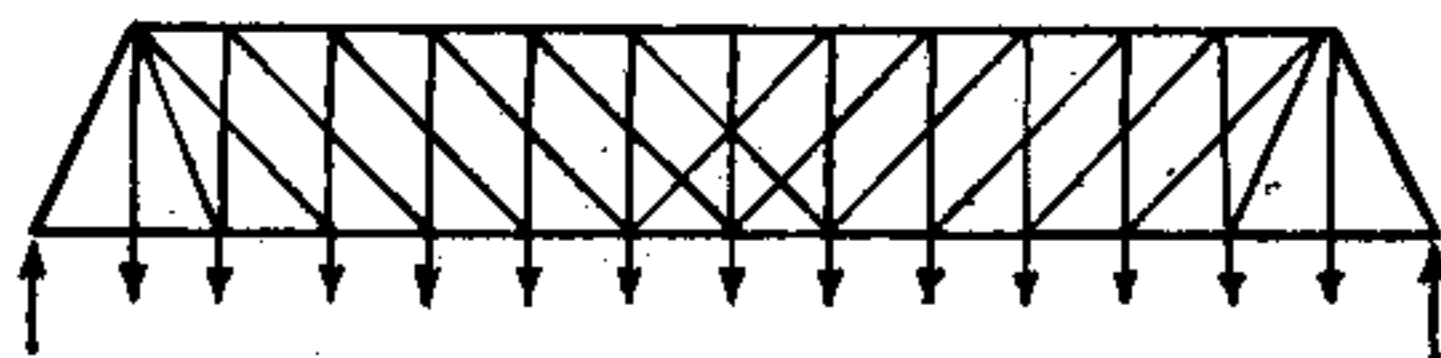
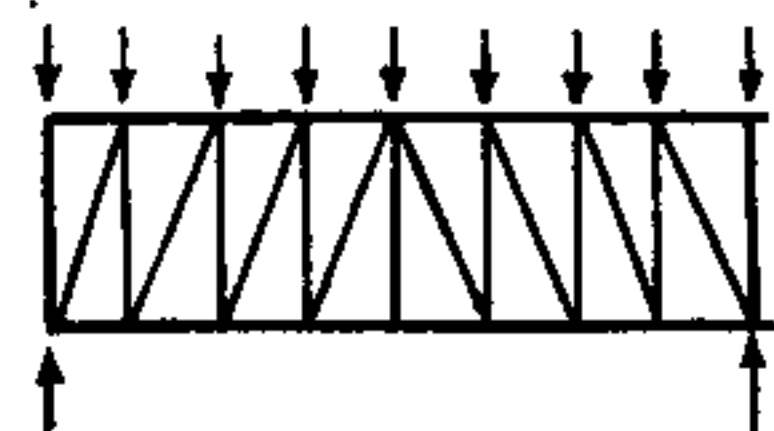
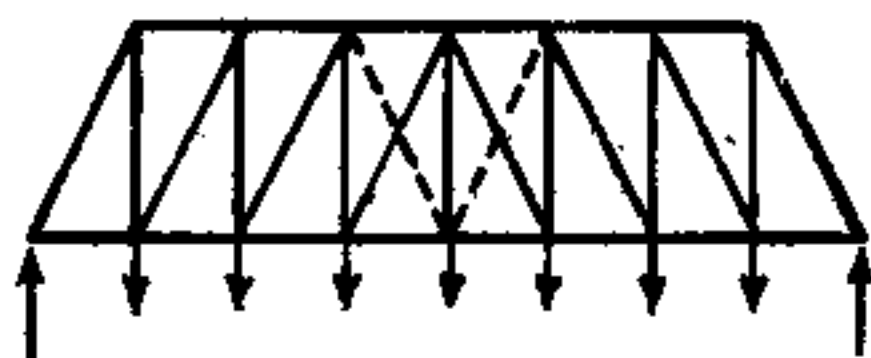
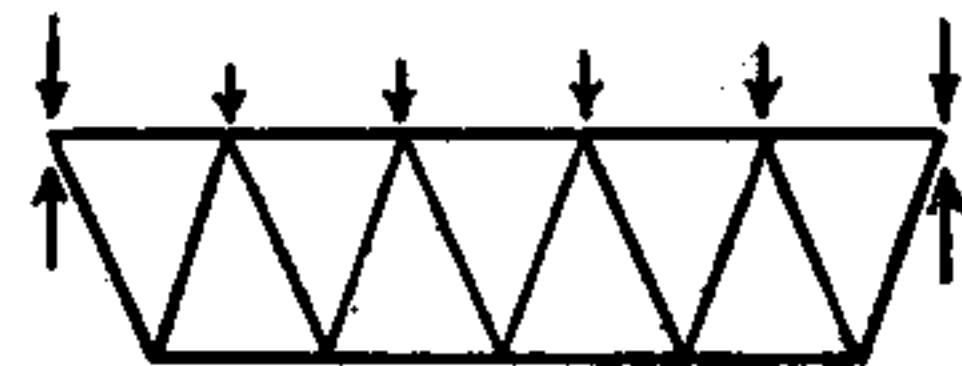
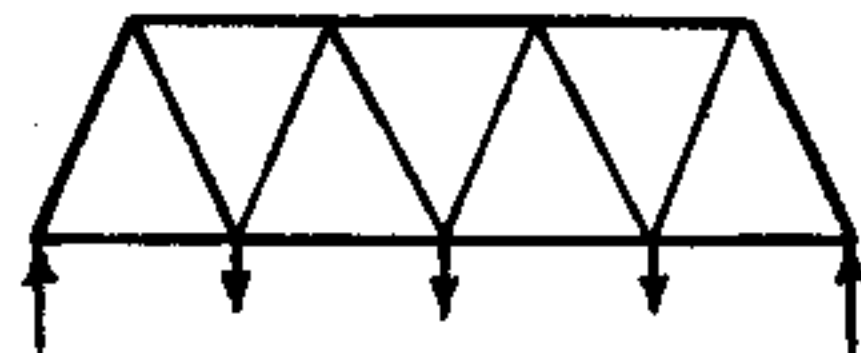
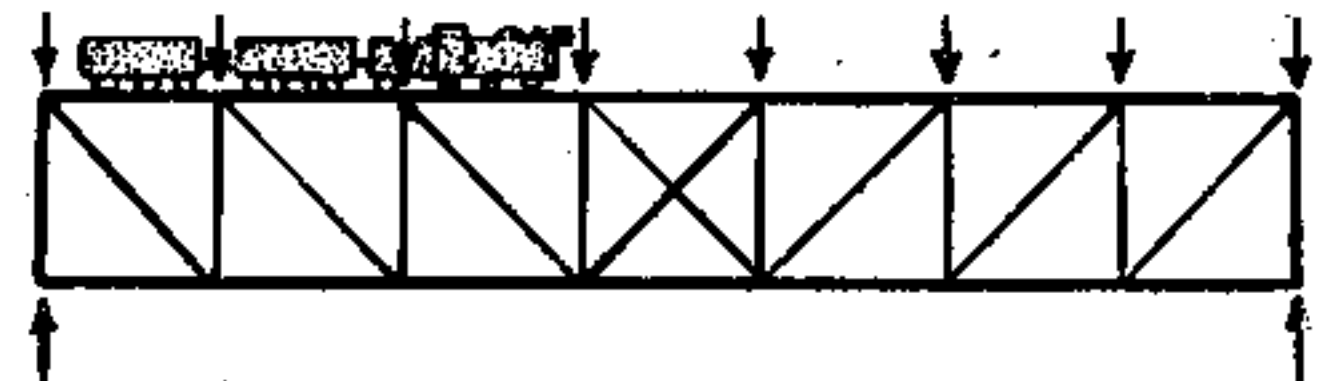
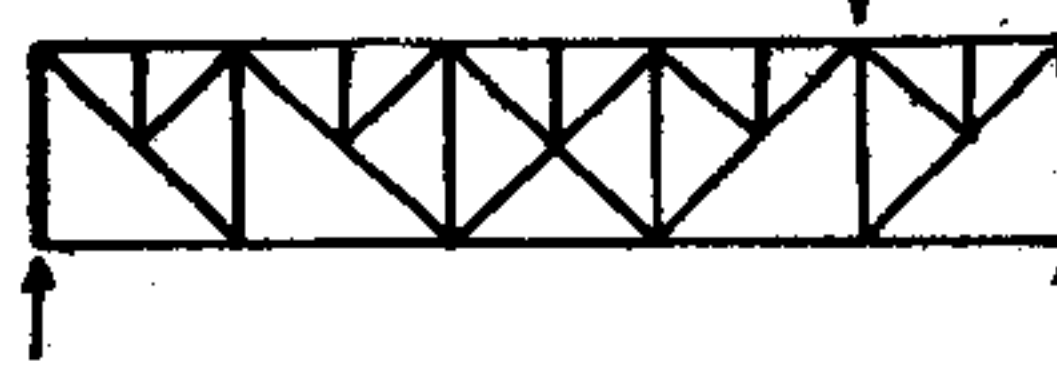
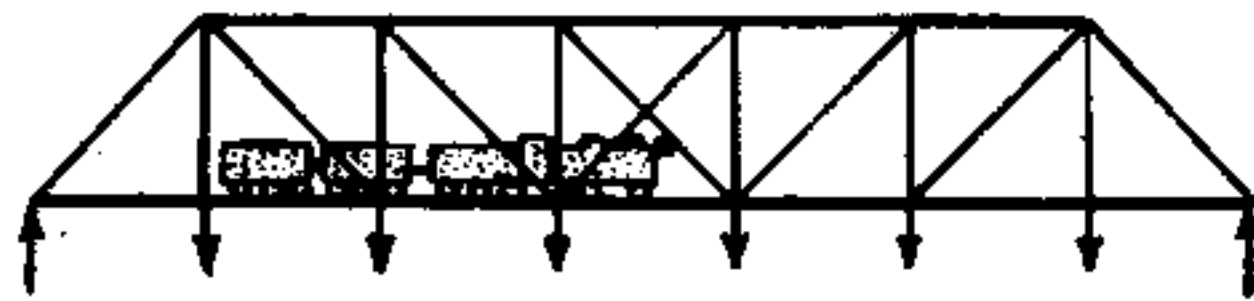


Fig. 1.



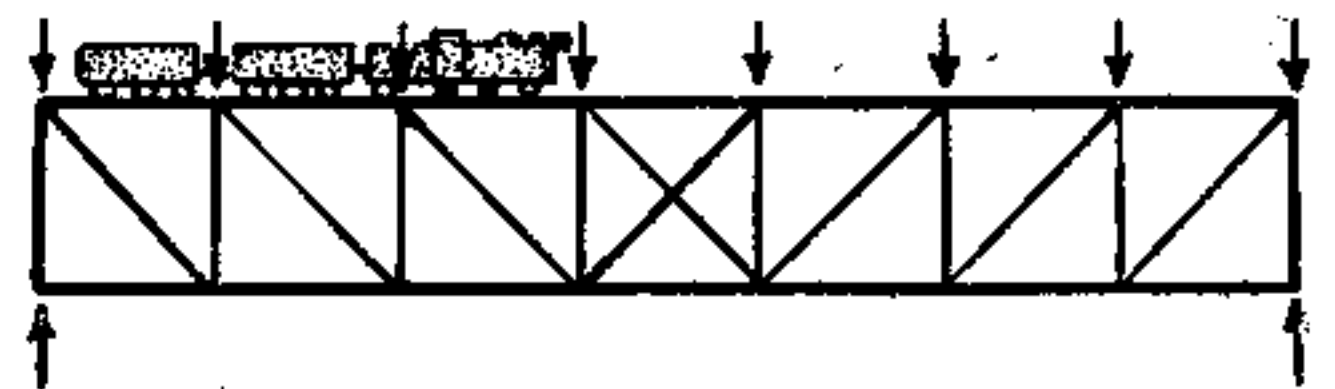
N-TRUSS WITH INTERMEDIATE BRACING

THROUGH TYPE

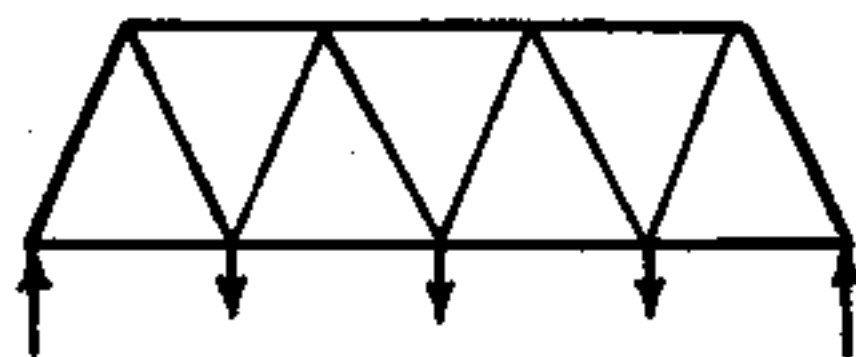


PRATT OR "N" TYPE

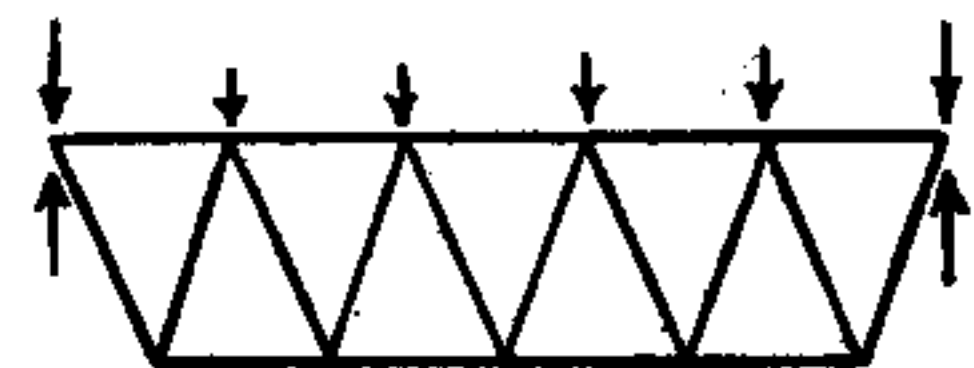
DECK TYPE



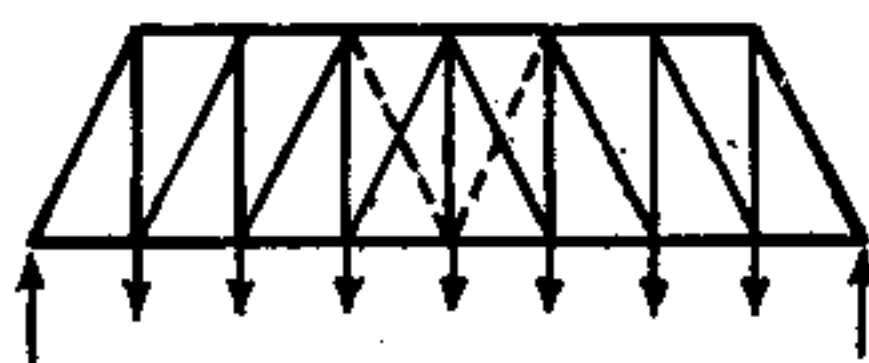
PRATT OR "N" TYPE



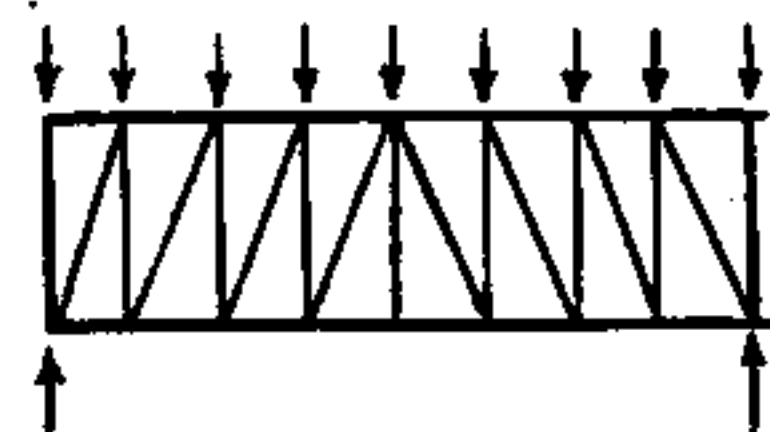
WARREN



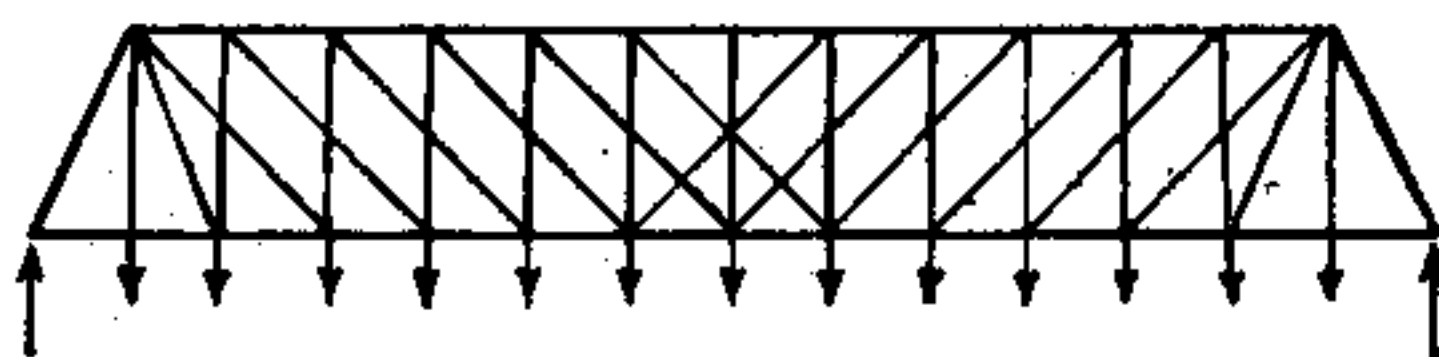
WARREN



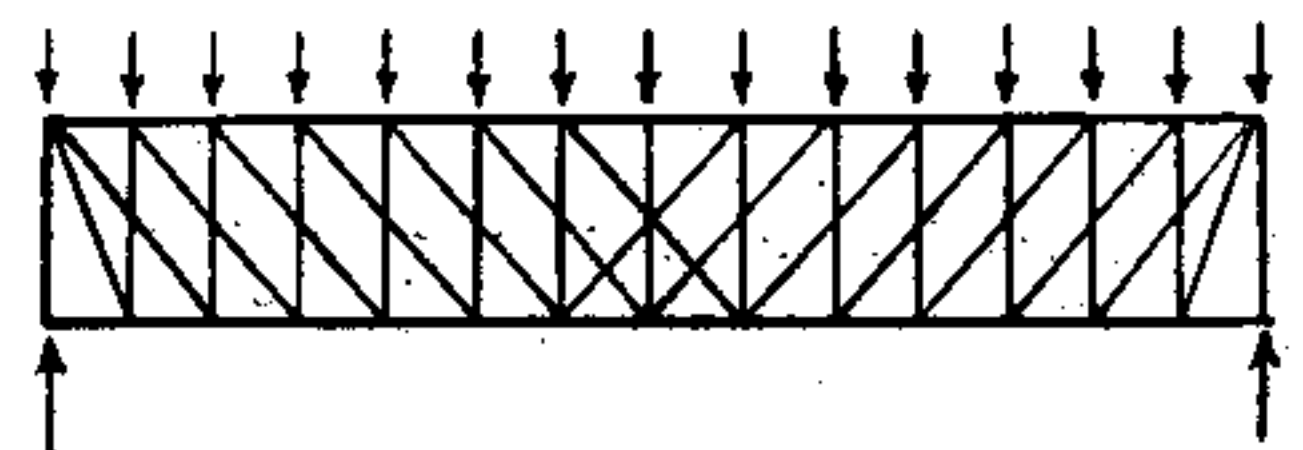
HOWE



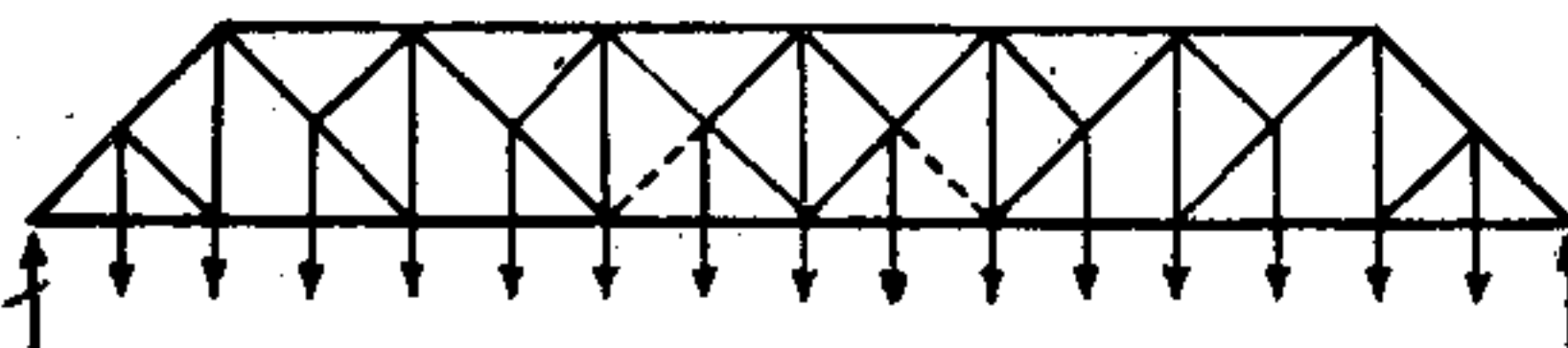
HOWE



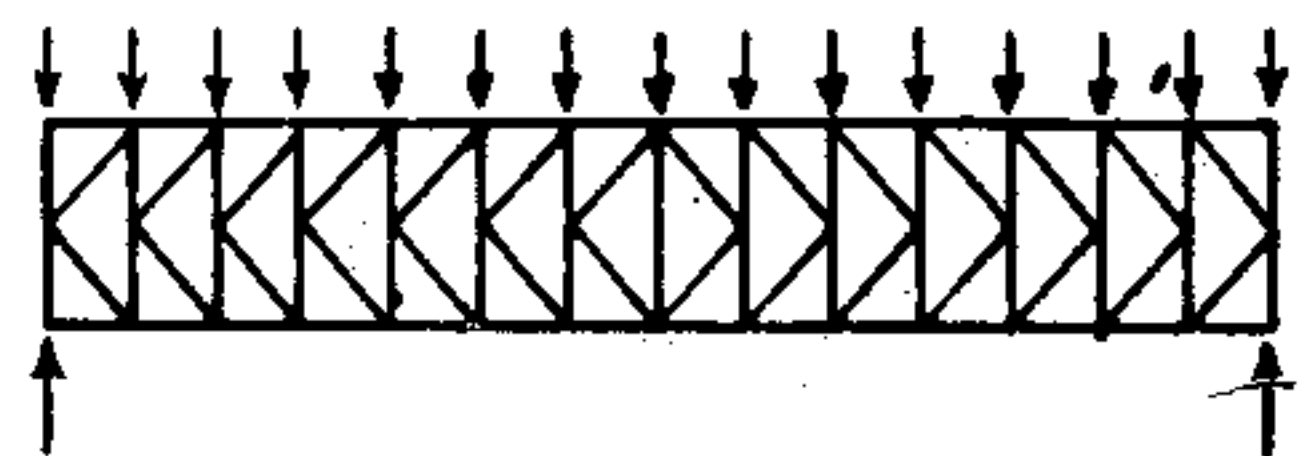
WHIPPLE



WHIPPLE



BALTIMORE

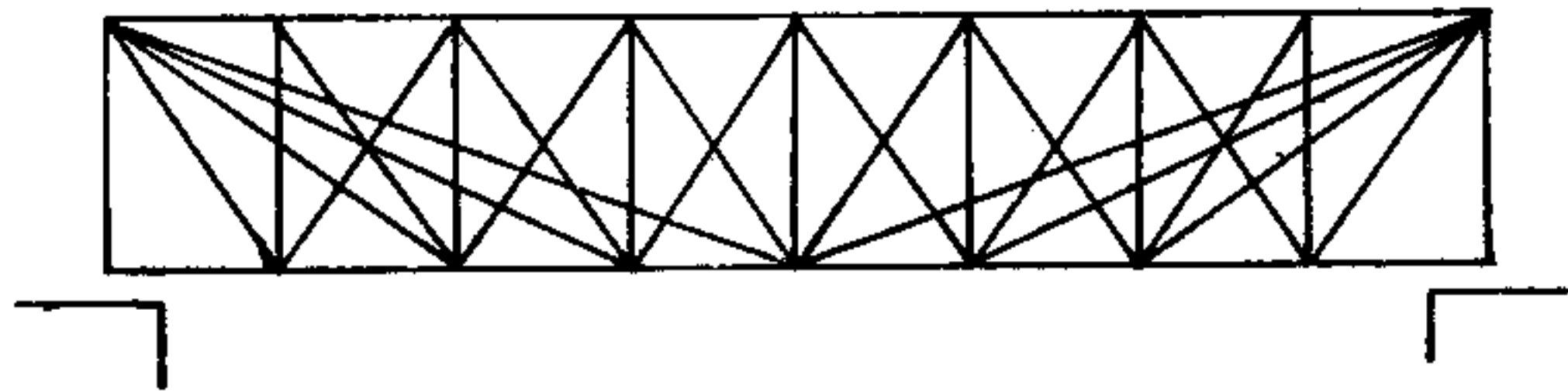


LATTICE GIRDER WITH "K" BRACING.

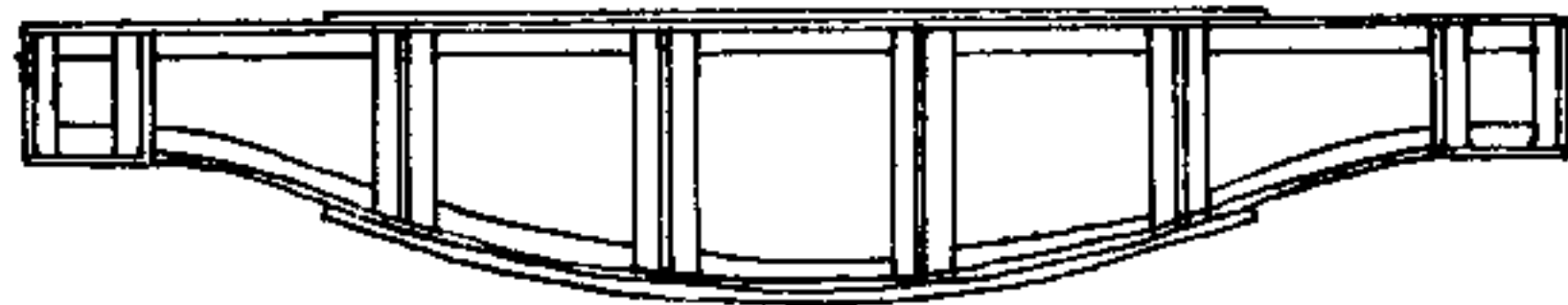
Fig. 1.
Types of framed structures.



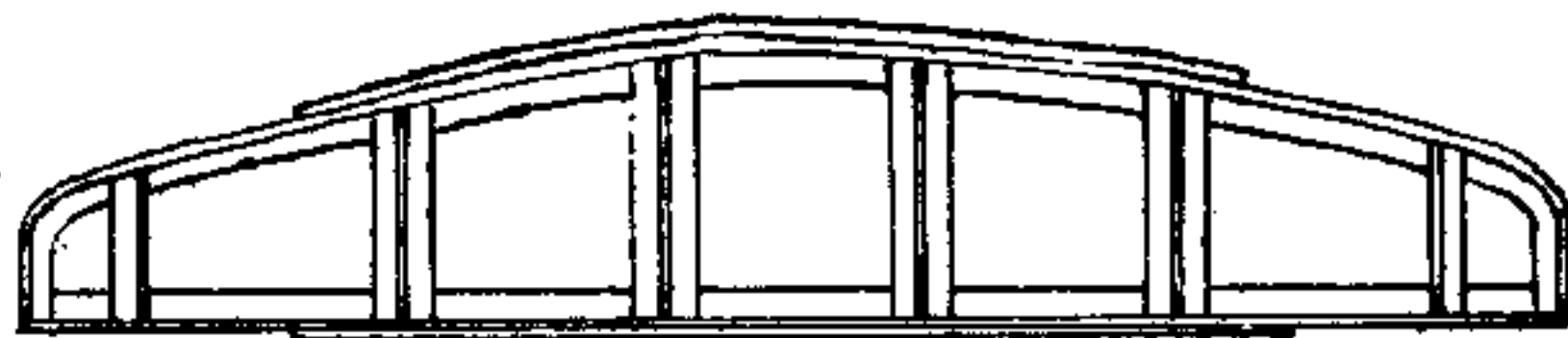
BOLLMAN TRUSS



FINK TRUSS



FISH BELLIED GIRDER



HOG-BACK GIRDER

Fig. 2.
Types of framed structures.

The most economical types of structures for bridging various lengths of gaps are stated below :

Usual span.	Type of bridge usually necessary.	Remarks.
40 ft–125 ft	Plate girder	But exception to the practice is the 271 ft span Main Avenue Bridge in Cleveland, Ohio. The Connecticut turnpike bridge designed by Dr. D. B. Steinman is of 387 ft span. In Germany the 528 ft span Frankenthal bridge and the Dusseldorf bridge of 676 ft span are now the longest plate girder bridges in the world.. Usually to carry rail-roads.
100 ft–250 ft	Riveted truss (Warren, Pratt or Petit, etc.)	
150 ft–200 ft	Pin-connected truss.	
Up to 600 ft	Simply supported truss.	With carbon steel.
Up to 750 ft	Simply supported truss.	With nickel steel, e.g. the new Ohio river bridge in Metro-polis is of 720 ft span.
Up to 2,000 ft	Cantilever bridge.	1,700 ft Firth-of-Forth bridge.
Up to 3,000 ft	Arch bridge	1,800 ft Quebec bridge.
		1,652 ft Bayonne bridge over Kill Van Kull, New York.
Above 4,000 ft to possible length of 7,010 ft	Suspension bridge.	Golden Gate—4,200 ft. Total length 8,981 ft.

Construction of bridge

The majority of the bridges of deck type plate girder were constructed by the railways. They have also constructed Pratt type truss and twin Pratt type truss close to Sealdah Station. These bridges are mostly over the roads and canals. The Railway Department have constructed two major bridges across the river Bhagirathi—one at Hooghly, popularly known as Jubilee Bridge, and the other is Vivekananda Bridge near Dakhineswar.

A few definitions of some non-standard bridges and different denominations of spans are necessary.

A *Draw Bridge* is a bridge a part or the whole of which can be moved to allow any river craft to pass underneath. It includes bascule bridge, vertical lift bridge and swing bridge.

A *Swing Bridge* is a kind of bridge structure which is pivoted at its centre and swings open horizontally to allow a ship or barge to pass. It is also known as Pivot-Bridge or Turn-Bridge. The weight of the shore-side portion of the structure is always heavier than that of the waterside portion.

A *Bascule Bridge* is a type of bridge structure which is hinged at the bank to allow a ship or barge to pass under it by lifting the projecting part over the water course and thereby lowering the part over the shore behind it. Synonyms of the bascule bridge are Counterpoise Bridge and Balance-Bridge. An example of the class is the Tower Bridge of London. They are nowadays made of light alloys.

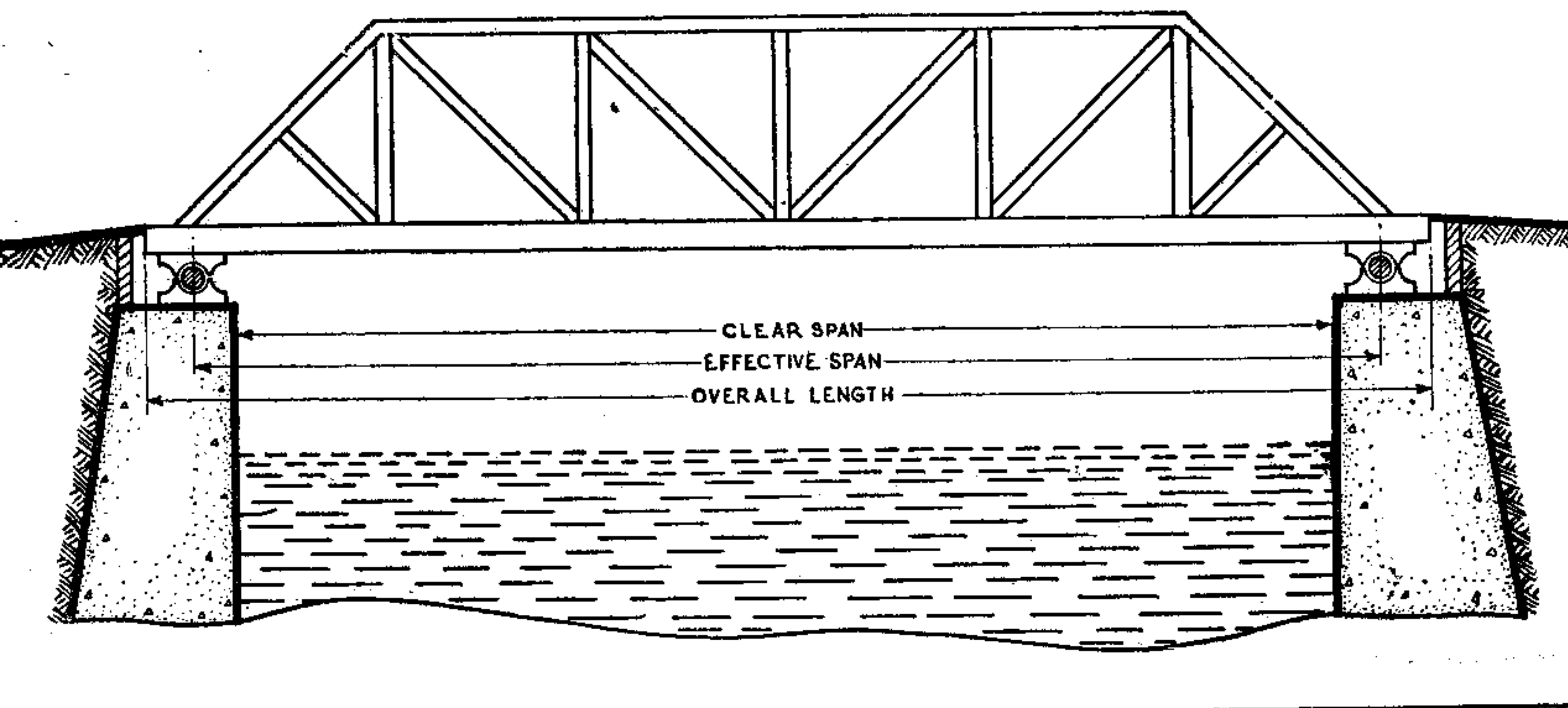


Fig. 3.

A typical section of a bridge resting on abutments.

A *Vertical Lift Bridge* is a kind of bridge structure a portion of which is bodily lifted vertically from its original position to a higher position to allow the barges or dingies to sail underneath. The first vertical lift bridge designed and constructed by Dr. J.A.L. Waddell in Chicago had a span of 130 ft. The longest span vertical lift bridge is a railway bridge over the Cape Cod Canal in Massachusetts to open a length of 544 feet.

There are generally three types of spans which the students of Bridge Engineering are to deal with. They are as follows :

The *clear span* of a bridge is the horizontal distance of clear unobstructed opening between two piers or two abutments or between one pier and the abutment. It is always less than the effective span.

The *effective span* is the horizontal distance between the centres of supports of a bridge structure. The length is a little more than the clear span.

The *overall length* of a bridge is the total length of the structure from one end to the other. It is larger than the effective span by the portions which extend beyond the centres of supports in opposite directions.

An *Overbridge* is one in which the road goes over the railways and an *Underbridge* is one in which the road goes under the railways.

Each bridge is divided into two parts—*substructure* and *superstructure*.

The *substructure* consists of foundation, piers and abutments. The end supports of the bridge are abutments and intermediate supports are called piers. A single span bridge has no piers but only two end abutments. It usually consists of masonry, in some form, including stone masonry, brick work and types of concrete work.

The *superstructure* of a bridge consists of a roadway on the deck with sleeper and rails and the beams, arch or cable or chain used to carry the road or railway from support to support.

In the design of a bridge several external forces come into play. A clear knowledge of them is essential. They may be classified as under :

1. The *live load*: It is the weight of the dense crowd to be taken into consideration for road bridges, or the weight of the heavily loaded road rollers as per specification of the

Indian Road Congress while for railway bridges it is the weight of the axle load of the heaviest locomotives as per I.R.S. specification.

2. *Impact factor* : It is the result of dynamic action of the live load due to irregularities of the permanent way or yielding of the structure.

3. The *dead load* : It consists of the weight of the main girders, flooring, wind bracing or the total weight of the superstructures exclusive of any part directly carried by the piers i.e. cast steel base of the rocker pins.

4. The *horizontal pressure* : It is due to the wind blowing transversely to the span.

5. The *longitudinal drag* : It is created by the friction of the train when suddenly braked (about $1/7$ th of the weight of the train).

6. The *centrifugal load* : It is due to radial acceleration of the train on a curved bridge.

7. *Temperature stress* is developed due to wide variation in temperature between the night and day from season to season equivalent to those produced by external load.

Details of these factors and the current formulae to deal with them may be available in any good text book on Bridge Engineering.

CHAPTER III

Major bridges of Calcutta and its surroundings

It is sometimes felt that the character of the bridges, wide streets, tall buildings and fine parks bespeaks the enlightenment and taste of the residents of a city. The graceful appearance and artistic ornamentation of a bridge in a city disclose the refinement of the city fathers, their advisory engineers and architects on whom the responsibility concerning construction devolves. They are mostly based on symmetry, harmony, simplicity, utility and beauty.

The New Howrah Bridge

(The New Howrah Bridge is the fourth longest cantilever bridge in the world. It is exceeded in length by the Firth-of-Forth Bridge in the U.K. (1,700 ft), Quebec Bridge (1,800 ft) in Canada, and New Orleans Bridge (1,575 ft) in U.S.A. (1955-58). Constructed under the joint efforts mainly of the Port Commissioners to replace the floating pontoon bridge of Howrah, it was opened to traffic in 1943.) It is a cantilever bridge across the Hooghly river connecting Calcutta with Howrah with a central Pratt type truss suspended at the centre. The whole deck is suspended from the main structure with vertical links to accommodate vehicular traffic of all classes, electric tram cars as well as pedestrian traffic. A camber is provided at the centre of the deck to facilitate the passage of river-going vessels without any difficulty. The river span was constructed without false-work on the river. Two travelling cranes from each shore moved along the top boom and erected the structure to the junction at midspan. The great bridge has a single main span of 1,500 ft length composed of cantilever arms of 468 ft on each side, 564 ft suspended span at the centre and anchor arms of 325 ft each on either shore. The shore spans are anchored at the two ends in such a manner that it counter-balances the weight of the across-the-river span. Details of the laying of foundation work are very difficult and intricate. They are shown in some plates (Plates 6-10).

Pontoon bridge of Howrah

(In order to establish a through communication between Sealdah and Howrah Stations and also between Calcutta and Howrah, a massive pontoon bridge was constructed across the Bhagirathi (Hooghly) as early as 1874 A.D. at a cost of £220,000, i.e., Rs. 3,411,440 on the southern side of the existing bridge. The middle floating section was detachable so as to allow the passage of vessels up and down the river. A small section of the middle portion of the bridge used to be dragged by steam launch and kept aside to keep a portion open to allow steamers whose funnels would have fouled the wooden and steel structures to pass freely through the gap for a short period generally during night and early morning depending on tide in the river. The length of the bridge was 1,528 feet between abutments with 48 ft wide roadway plus 7 ft wide footpaths on either side. The proposal was made as early as 1855-1856, i.e., the period of commencement of railway lines in Howrah but the idea was dropped in 1859-60, revived again in 1868 and ultimately the necessary Act was passed in 1871 for the construction of the pontoon bridge of Howrah. It was originally a toll bridge. However, that bridge is no more in existence, the story of which has become a history. It was replaced in 1943 by a permanent imposing steel structure, popularly known as the New Howrah Bridge, with two cantilever arms of 468 ft long to hold a central suspension span of

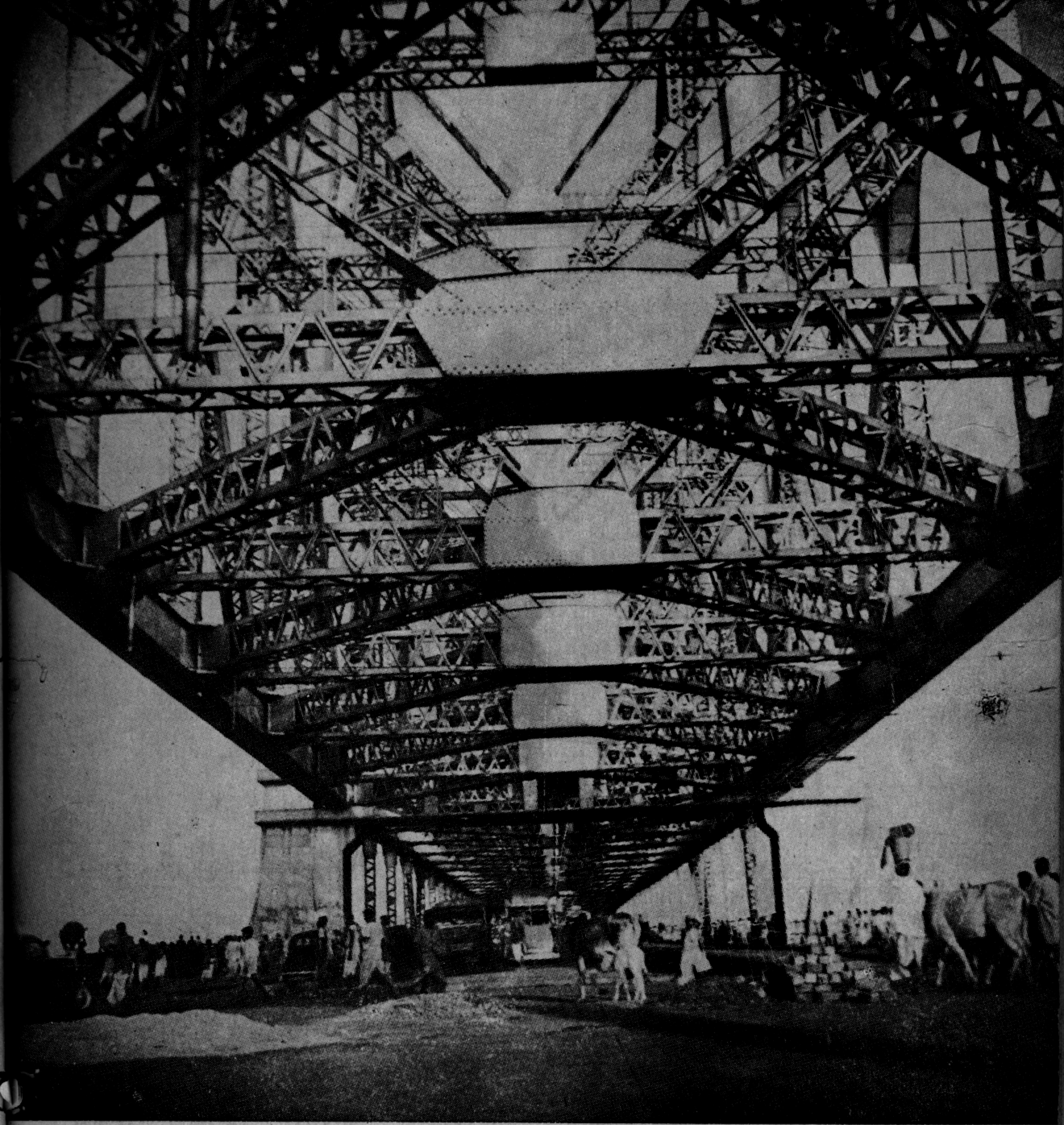


Plate 3.

A view through Howrah Bridge showing deck, pillar base and the fabricated structure.

Photo—B.

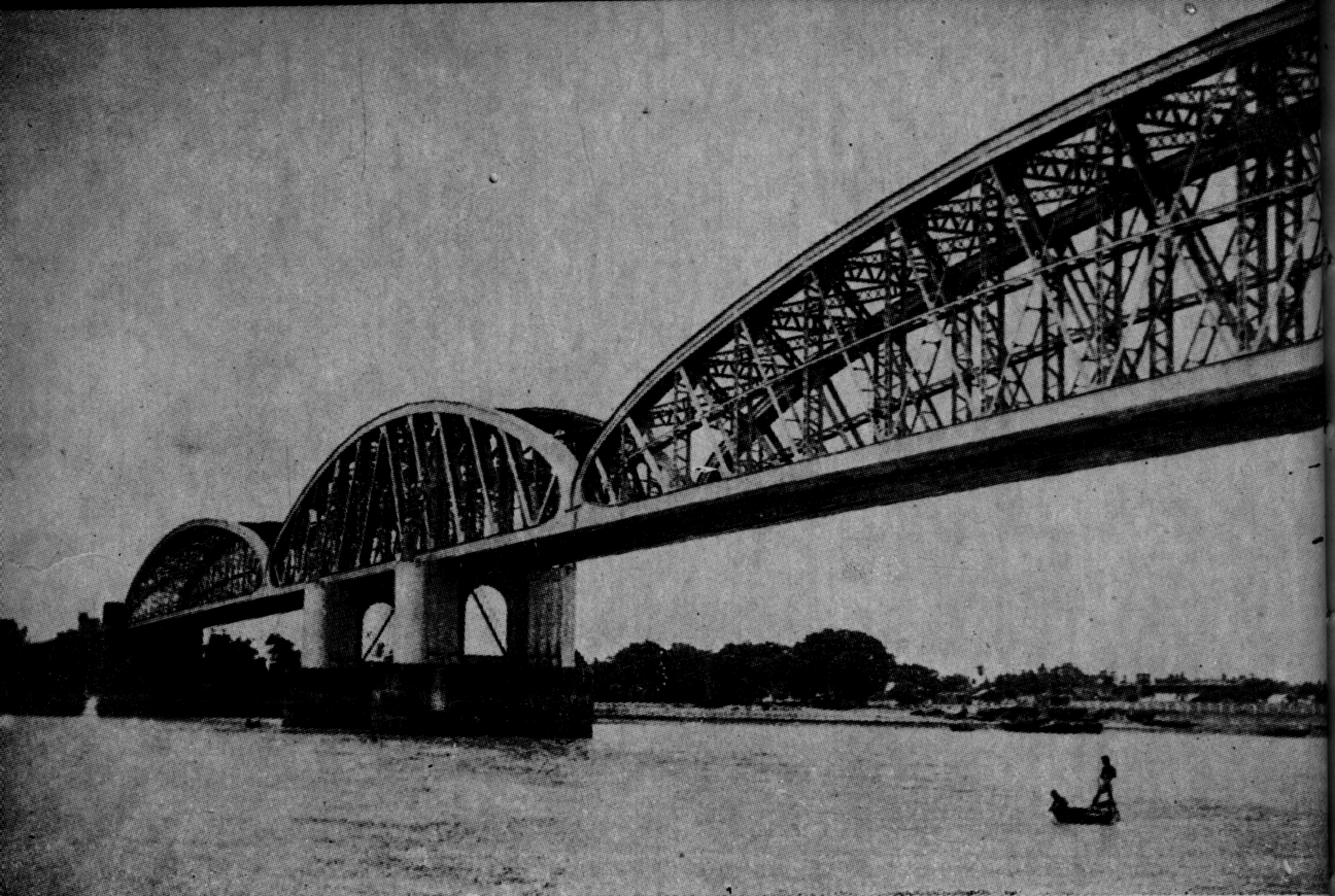


Plate 4.

Jubilee Bridge: View showing the piers of the three spans.

Photo — B. Kar.

564 ft located just north of the old bridge.) It has two anchor arms of 325 ft each on either bank connected with the anchor piers. The maintenance of the bridge structure lies with the Commissioners for the Port of Calcutta.

As early as 1876 the Harrison Road, after the name of the illustrious Chairman of Calcutta Corporation, now renamed as Mahatma Gandhi Road, was opened out so as to connect the two railway termini of Sealdah and Howrah through the then floating bridge of Howrah. The eastern end of the bridge was in line with the newly constructed Harrison Road.

Jubilee Bridge

(Though named as Jubilee Bridge to commemorate the jubilee celebration of the reign of Queen Victoria, the then Empress of India and Queen of England, it is popularly known as Naihati or Hooghly Bridge across the river Bhagirathi (Hooghly) connecting Naihati Junction of Eastern Bengal Railway with Bandel Junction on East India Railway of olden days.) However, both the sections have now come within the jurisdiction of Eastern Railway.) The bridge was designed for a double line of railways and is located where the width of the river was only 1,200 feet. The superstructure consists of three sections spanned by girders of bow-bent profile with straight bottom booms of ordinary box or trough section. The central double cantilever measuring 360 feet and two main side spans of 420 feet each account for 1,200 ft total span.

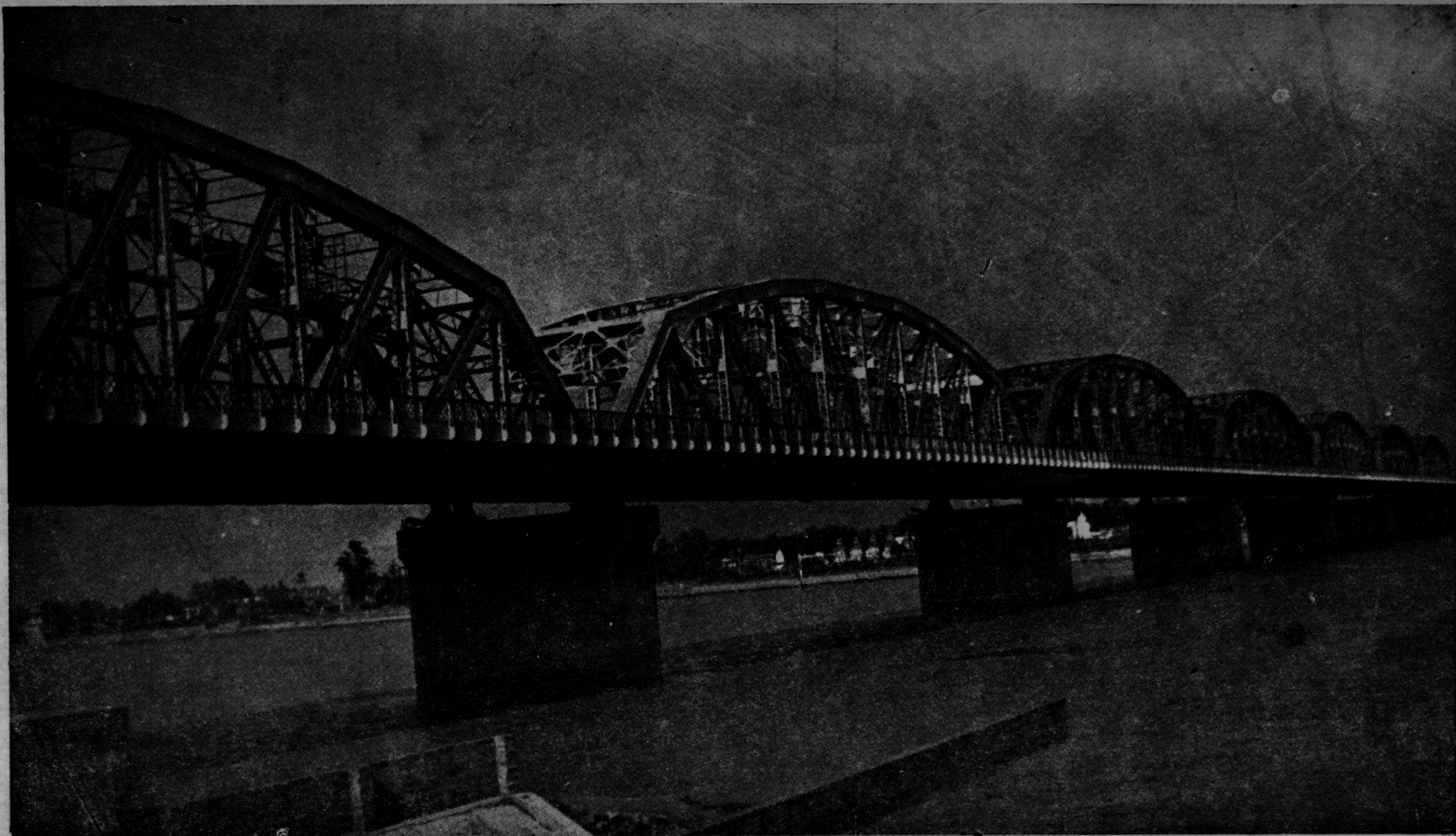


Plate 5.
Vivekananda Bridge: Side elevation.

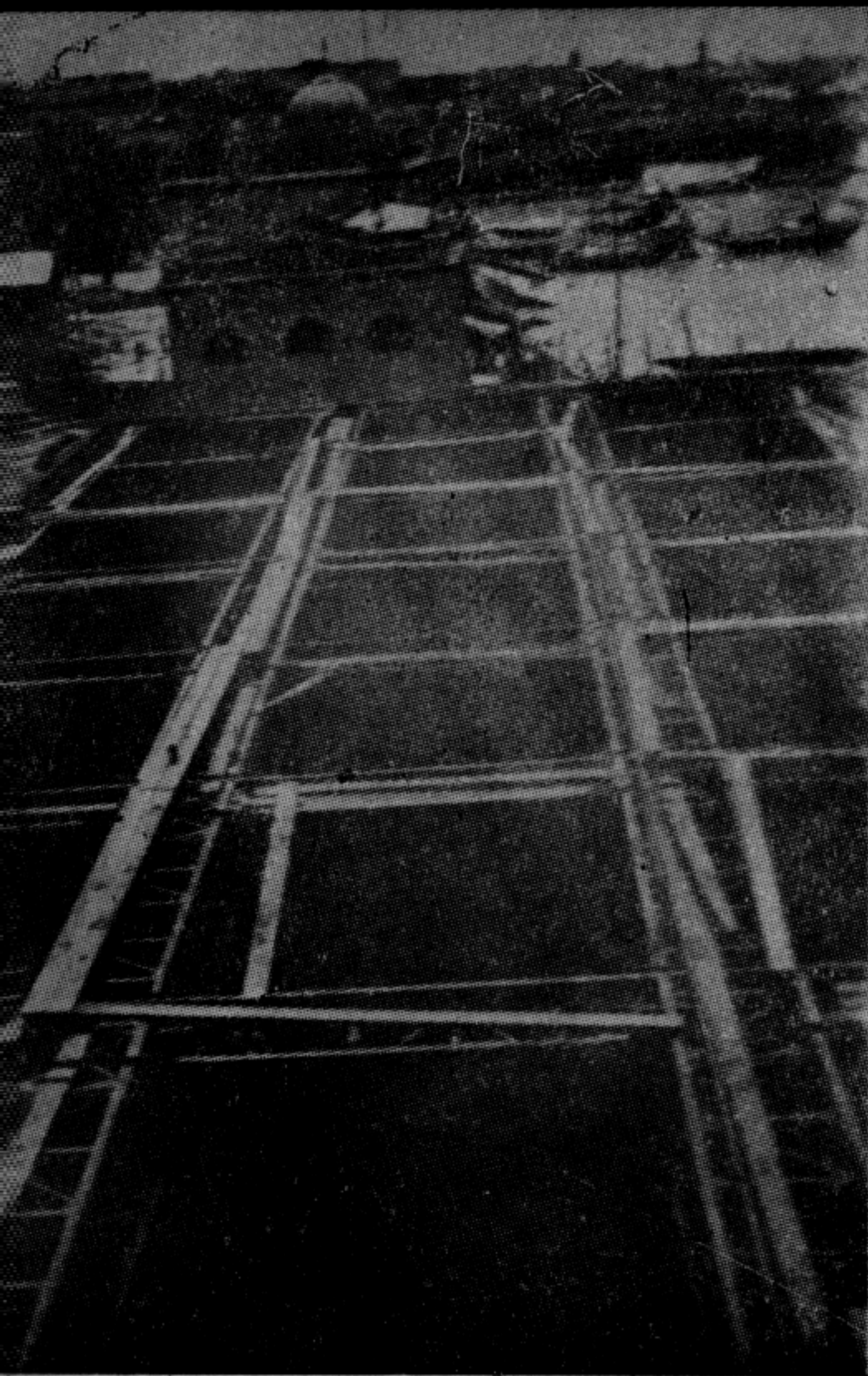


Plate 6.



Plate 7.

Details of foundation of the Howrah Bridge during construction.

Photo—Author

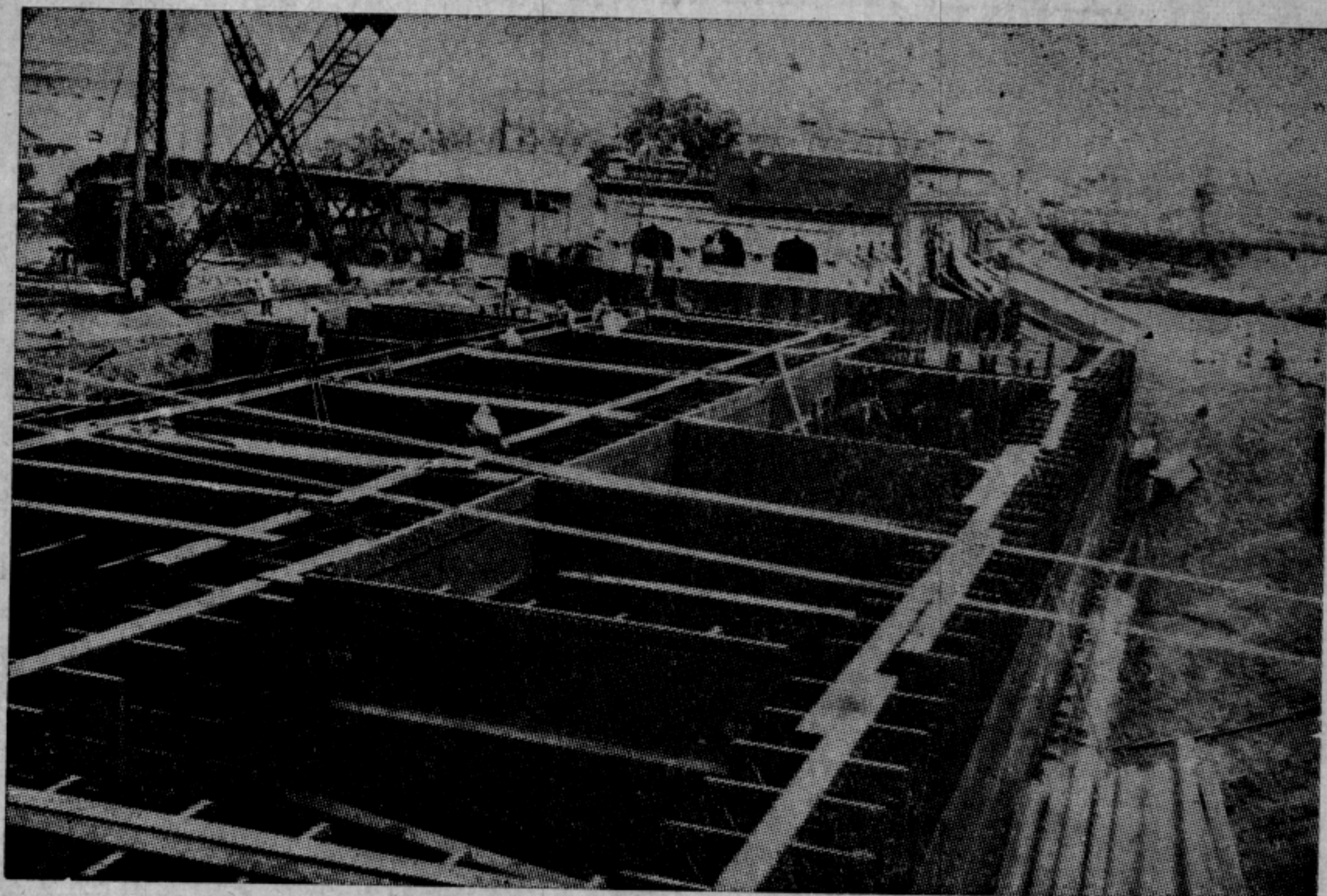
between centres of the bed blocks. The cantilever is carried at a height of 53 feet clear above datum of two river piers pitched 120 feet 6 inches apart from centre to centre. It has the advantage that it locates the pier in comparatively shallow water and it leaves the widest span of 520 feet on each side of the river piers. (The steel material weighing 3,465 tons was received on the 18th March 1886 and the bridge was completed on the 22nd December, 1886 without any accident or loss of life.)

(The erection work was done by the use of two floating pontoons of 25' x 26' by 9 feet deep. However, Sir Bradford Leslie, K.C.I.E., M.Inst.C.E., once the Chief Engineer, Calcutta Corporation, the designer of the bridge disclosed his original ideas during discussion of his paper at the meeting of the Institution of Civil Engineers, London. His original proposal was to span the river by two arches spanning from the central pier. The arches were intended to be constructed of the old iron rails taken out of the railways as the line was relaid with steel. The old rails were worth only 36 shillings a ton at Calcutta at that time. With the raw material so cheap a very massive bridge would have been erected at a comparatively small outlay. The proposal however did not convince the railway company's consulting engineers and was abandoned in favour of a more orthodox type of construction.)

(There was criticism fifteen years after the bridge was in commission on the design of the above bridge in Indian Engineer (November 4, 1901) which reads thus:

"The design is considered inconsistent, and the ideas produced by a study of its distinctly conflicting..... In the Jubilee Bridge there is, we recognise, a violation of ideas, for the centre girder is cantilevered the wrong way and an

Plate 8.
Main pier foundation—
Calcutta end.
Howrah Bridge.



impression is left on the mind that the piers have got misplaced from their natural position, viz., where the girders met. We regard this as a palpable loss of opportunity for aesthetic treatment")

Almost at the same time another bridge across Rohri Channel of the Indus was under construction. In 1883-84 the foundation work of the cantilever bridge was started but the work of erection of superstructure had to be suspended till November 1887 when the steelwork of the main bridge structure began to arrive at site.

Originally to span the gap of over 800 feet several types of designs were placed for consideration, e.g., a stiffened suspension bridge, a three-hinged arch and a cantilever bridge. Ultimately, after due consideration it was decided to adopt the design of a cantilever bridge

by Sir Alexander Rendel on Rohri Channel and a three-span bridge resting on piers and abutments across Sukkur Channel.

The bridge, designed to accommodate a single broad gauge rail track, is composed of two anchored cantilever arms 310 ft long founded on the banks of the river and a central suspended span of 200 feet to make a total span of 820 feet. The clear span is 790 feet and the height of the uprights is 150 feet. The cantilever portions were constructed from either side without any false works in the river. The width between centres of main uprights at bed plate is 100 feet and between centres of main members at the end

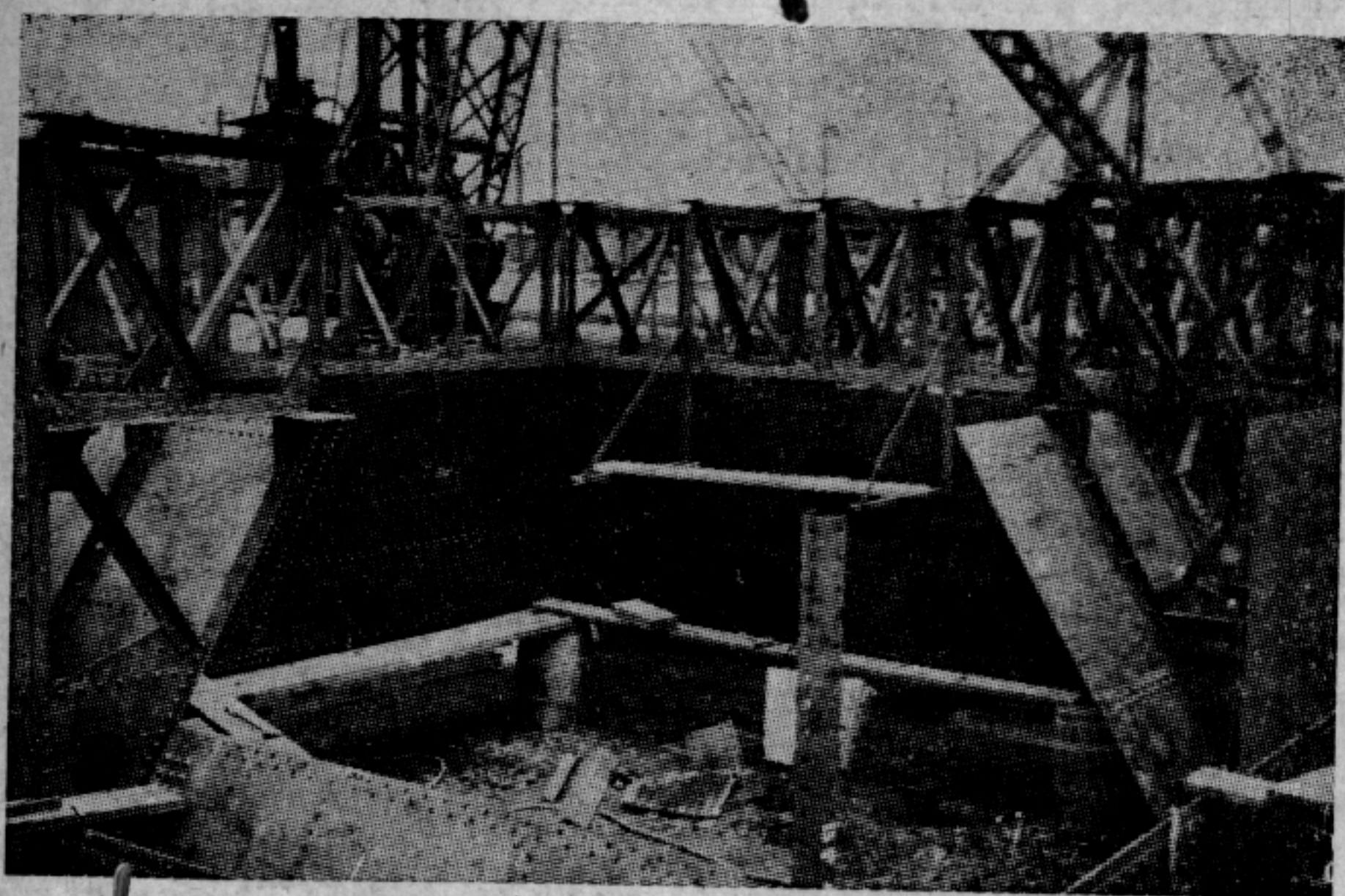


Plate 9.
Details of cutting edge of the anchor block.
Howrah Bridge

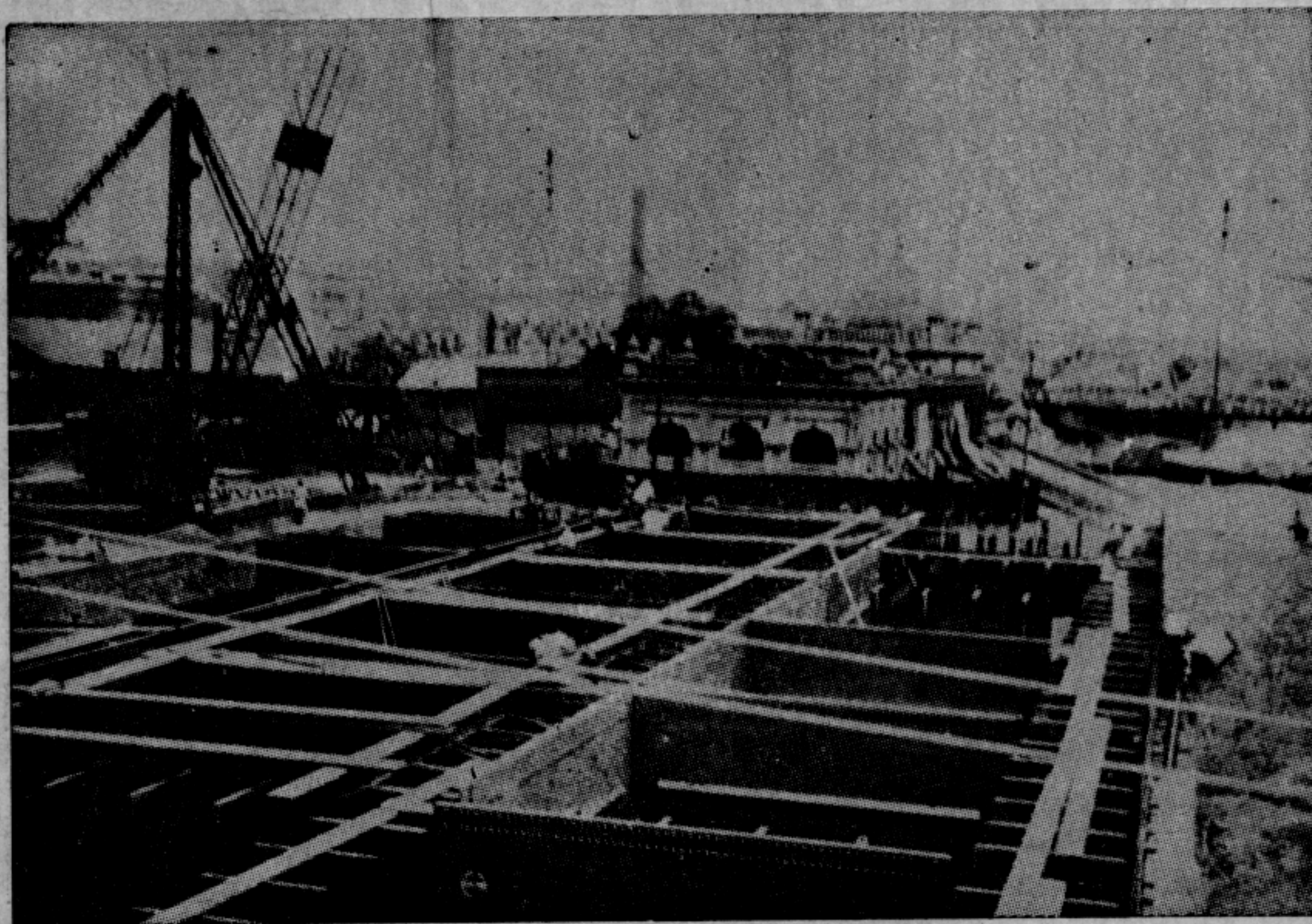


Plate 10.
Sinking of caisson
structures.
Howrah Bridge.

of cantilever is 20 feet. The shore guys are the most heavily strained part of the structure, the stress provided for being 1,200 tons. The total weight of steelwork is 3,300 tons. The whole structure was fabricated by Messrs Westwood and Baillie of Poplar, London. The bridge was completed in February 1889 and was opened by His Excellency Lord Reay, Governor of Bombay, in the absence of His Excellency, the Viceroy Lord Landsdowne on the 25th March, 1889. The Sukkur Bridge is also named as Landsdowne Bridge. From February, 1889 to March, 1890 it was the longest span cantilever bridge of the world when the distinction was taken away by the opening of the Firth-of-Forth Bridge in Scotland by two spans of 1,710 feet each in March 1890. There is a tablet in the Block House Wall both in English and Urdu, which runs thus :

N. W. Ry. The bridge was designed by Sir A. M. Rendel, M.I.C.E., K.C.I.E., Const. Engr. to the Secy. of State for India. Messrs Westwood Bailie, London were contractors for the iron works. The bridge was erected by F. E. Robertson, A.M.I.C.E., Suptg. Engineer and M. S. N. Hecquet, Asst. Engineer.

Bally Bridge (Vivekananda Bridge)

(It is the bridge across the river Bhagirathi (Hooghly) on the Calcutta Chord Railway to connect Dum Dum Junction with Dankuni Junction, a station on the Howrah-Burdwan Chord Line, i.e., for linking Howrah with Calcutta by train.

The bridge was christened as Willingdon Bridge after the name of the then Viceroy and Governor-General of India, Lord Willingdon, who inaugurated the opening of the bridge. In independent India it has been again renamed as Vivekananda Bridge after the Great Saint whose centenary celebration will be inaugurated this year (1962). It is also known as Bally Bridge after the name of the locality on the western side of the river.)

The bridge over the water portion consists of seven spans of 350 ft each. They rest on brick piers placed at 360 ft apart from centre to centre, founded on caissons 70 ft by 37 ft and sunk up to depths ranging from 120 to 130 ft below mean sea level. On each bank there are shore spans of 80 ft each. The total length of the bridge excluding shore spans

composed of plate girders is 2,511 feet. The structure was originally designed to receive a double line railway track for Heavy Mineral Standard Loading with allowable impact factor as per Bridge Rule.

The floor structure was subsequently modified to accommodate an 18 feet wide roadway to carry the moving load of a 20 tons steam roller with uniformly distributed load of 45 lb/sq ft and 8 feet wide side-walks to carry a distributed load of 56 lb/sq ft on each side of the main bridge. The distance between parallel beams is 38 feet, centre to centre. The girders are modified Petit trusses but the cross girders are slung below the bottom boom and further extended on either side to carry reinforced concrete roads and pathways. Suitable mild steel railings are provided along the outer edges of the side-walks. The weight of the steel structures for each span comes to 2,406 tons. The total cost of construction was Rs. 18,972,413.

CHAPTER IV

Bridges across Circular Canal

Now, let us turn our attention to the road and railway bridges in the city proper. Road bridges have connected the main roads beyond the original jurisdiction of the city. Starting from the northern side of Calcutta from its junction with the Hooghly at Baghbazar the first canal is the Circular Canal popularly known as Marhata Ditch. The Circular Canal commences its journey from Baghbazar and proceeds eastward. After passing under the Belgachia Bridge the Circular Canal branches off as New Cut Canal. After a traverse of more than a mile of the New Cut Canal from the starting point the Krishnapur Canal emerges and moves in a northerly direction. The Circular Canal after its junction with the New Cut Canal moves southward along the eastern part of old Calcutta and joins or takes the name of Beliaghata Canal which ultimately meets the New Cut Canal in another place forming a loop. Beliaghata Canal as well as the New Cut Canal is navigable for small river craft and barges. Another canal known as Tolly's Nullah starts from the southern end of the original city, a little beyond Fort William from the river Hooghly. The place is known as Hastings.

Plate II.

Draw Bridge at the mouth of Circular Canal near Baghbazar.

Photo—B. Kar.

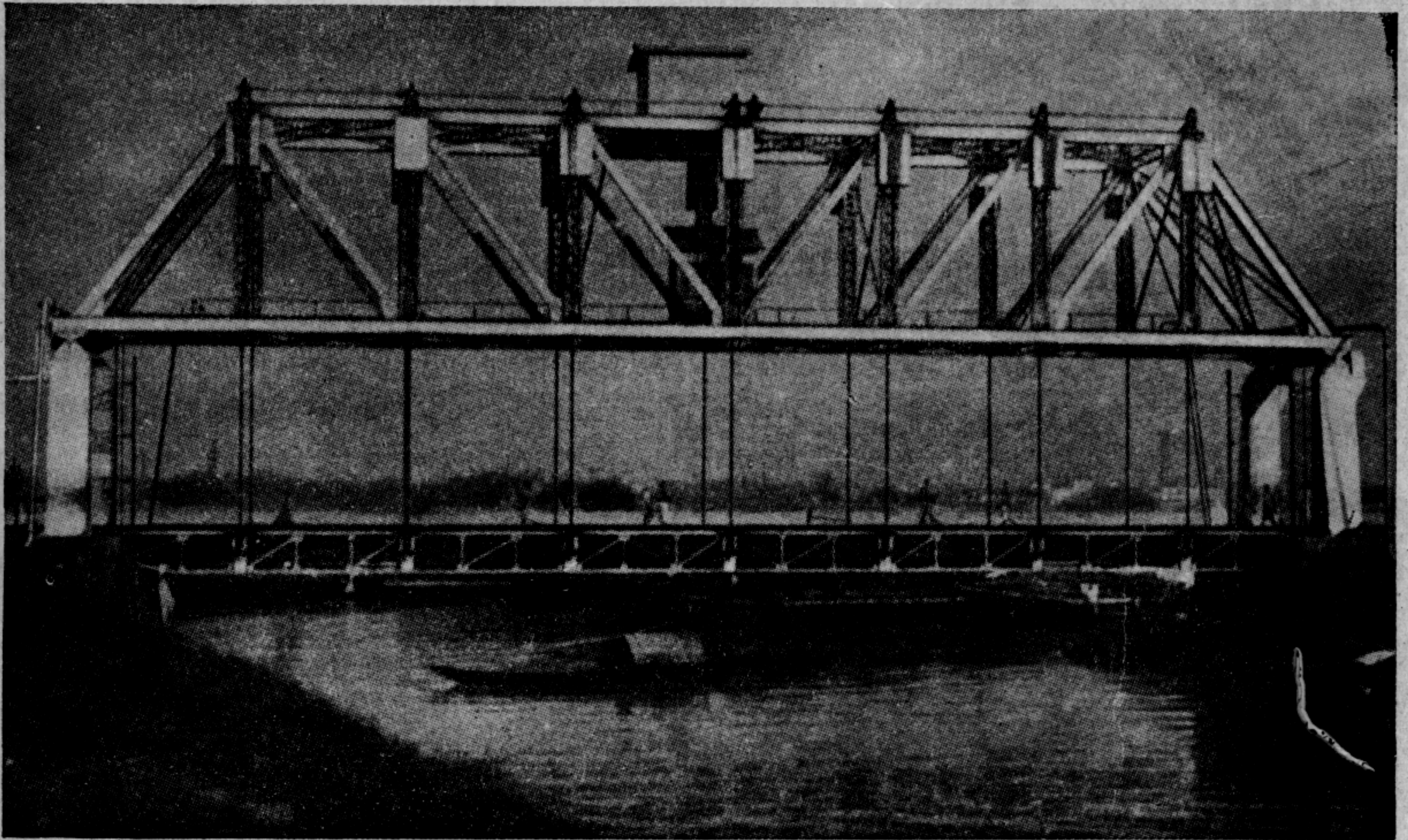
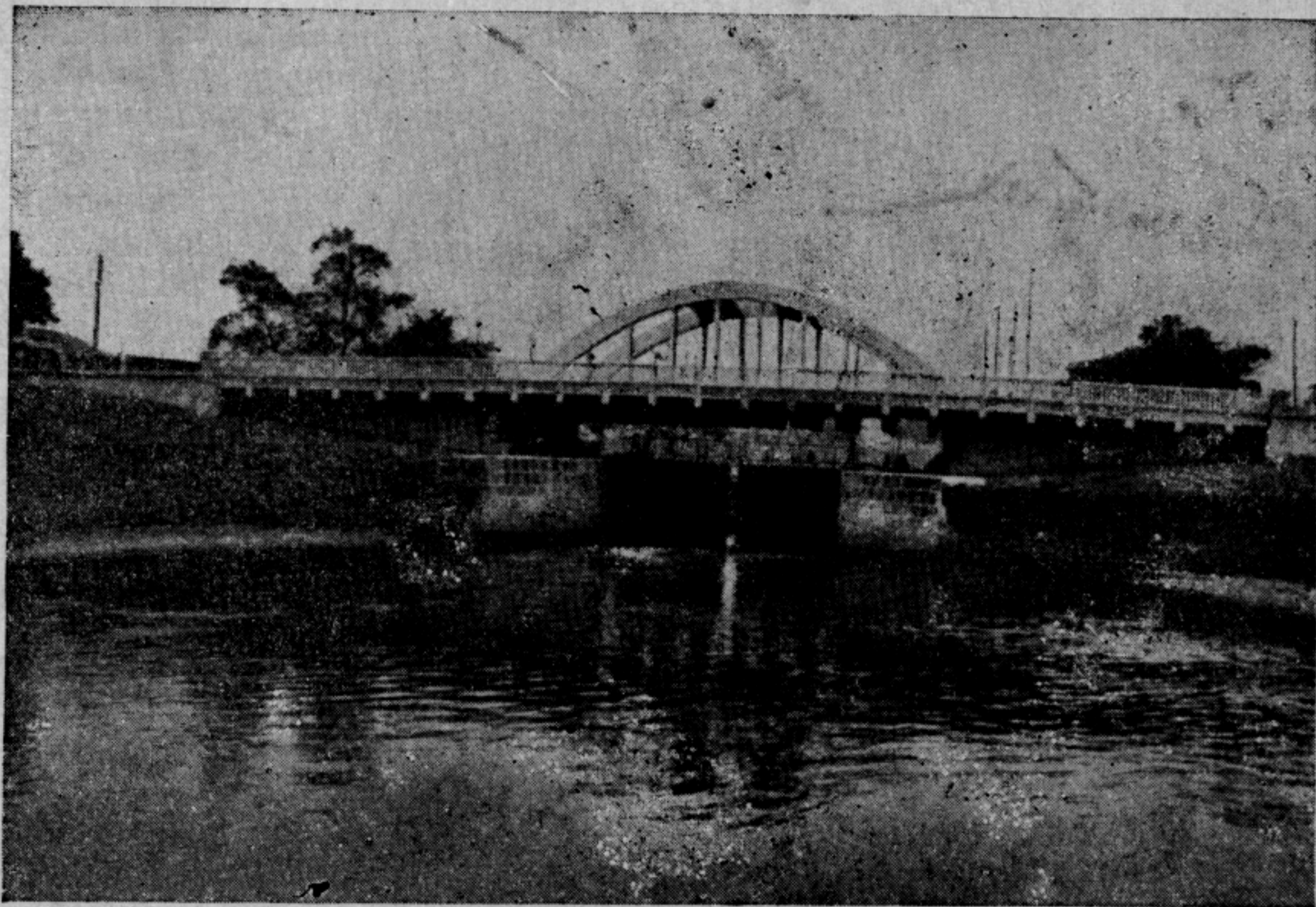


Plate 12.
Chitpore Bridge across
Circular Canal.

Photo—Author.



A considerable portion of Tolly's Nullah is known as Adi Ganga i.e. the original course of the Ganga. Reference to Adi Ganga course of the Bhagirathi can be had in Chaitanya Charitamrita, Chaitanya Bhagabat and also in Mangal Kavyas where the voyages of princely Bengali traders are nicely depicted with reference to places known along this river.

Bridges across Circular Canal

In describing the minor bridges (for our purpose) across the Circular Canal, the first in the series is:

1. A *Vertical Lift Draw Bridge*, a steel Pratt truss from which is suspended a single line railway track to carry the goods, specially jute and other commodities, necessary for nearby presses and factories of Cossipore. It is situated almost at the mouth of the Circular Canal. The bridge is vertically lifted to allow the river-going country vessels during flood tide to pass under it without any obstruction. This ingenious device was adopted to avoid the placing of the bridge at a higher level permanently having the approach



Plate 13.
Barrackpore Bridge across Circular Canal.

Photo—Saurananda Chatterjee.



Plate 14.
Belgachia Bridge across Circular Canal.

Photo—T. Chandra.

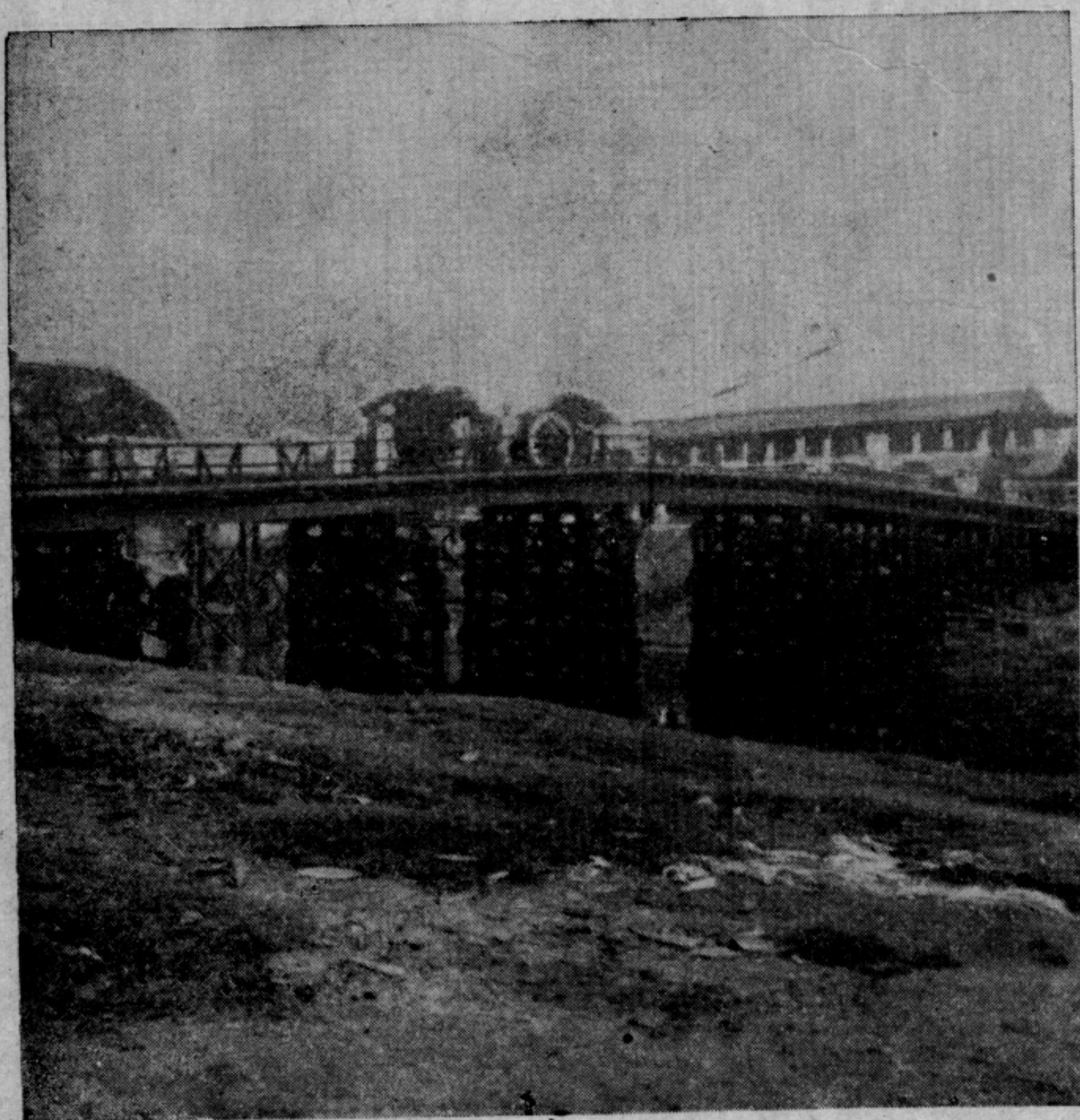


Plate 15.
Temporary Sal Bullah Bridge.

Photo—Saurananda Chatterjee

embankments with ruling gradient on both sides of it to carry the railway track. In that case the cost of engineering works in building high embankments on both sides would have been higher and the cost of land acquisition and compensation would have been much greater than in the case of the present one due to large areas to be occupied to accommodate the side slopes of the embankments. The legal easement rights of the people might have been infringed, which would have resulted in raising serious objection by the local inhabitants against such construction. The bridge carries the railway track on a platform suspended by means of a series of vertical mild steel heavy rounds; the top ends of each are connected by wire ropes which pass over pulleys and are connected with the counterweights each to each. Series of pulleys are connected with two horizontal shafts placed on the top booms of the bridge structure. Two shafts are geared with the electric motor which raises vertically all the suspension round bars uniformly and simultaneously. The single span truss is placed at a higher level on bearings up to which the rail-bearing structure can go. This is a type in itself which has its counterpart at the mouth of Tolly's Nullah. They are the properties of Calcutta Port Trust.

2. (The next in the series is *Chitpore Bridge* which connects Cossipore Road with Galiff Street. Here, Lower Chitpore Road also joins near the southern approach to the bridge.) It is a single span bowstring girder reinforced concrete bridge of 78'-0" central span with two approach spans of 49'-4" on either side (constructed by the Calcutta Improvement Trust. It has a clear headway of 19'-6" above the deck having 40 ft road

width earmarked for high-speed traffic and with 10 ft sideways on either side for slow-moving traffic.

carries also a 10 ft wide footpath on each side on the cantilever wings. The approach grade is one in thirty (1 : 30). The approximate cost of construction was Rs. 2 lakhs nearly just over a quarter of a century ago.

3. *Barrackpore Bridge*: (This bridge negotiates Barrackpore Trunk Road with extension of Cornwallis Street or Upper Circular Road at Tallah.) It is also an example of reinforced concrete bowstring girder of 100 ft span with clear headroom of 21'-9 $\frac{3}{4}$ " with a fast-moving traffic-way of 38'-6" and two lanes of 9'-3" width for slow-moving traffic on either side. It carries also 10 ft wide footpaths on both sides of the bridge. The grade of approach is only one in thirty. The approximate cost of construction nearly twenty-six years ago was just over Rs. 4 lakhs.

(Just adjacent to the bridge is a



Plate 16.

Collapsed steel structure with Sal Bullah Bridge in the background.

Photo—Saurananda Chatterjee.

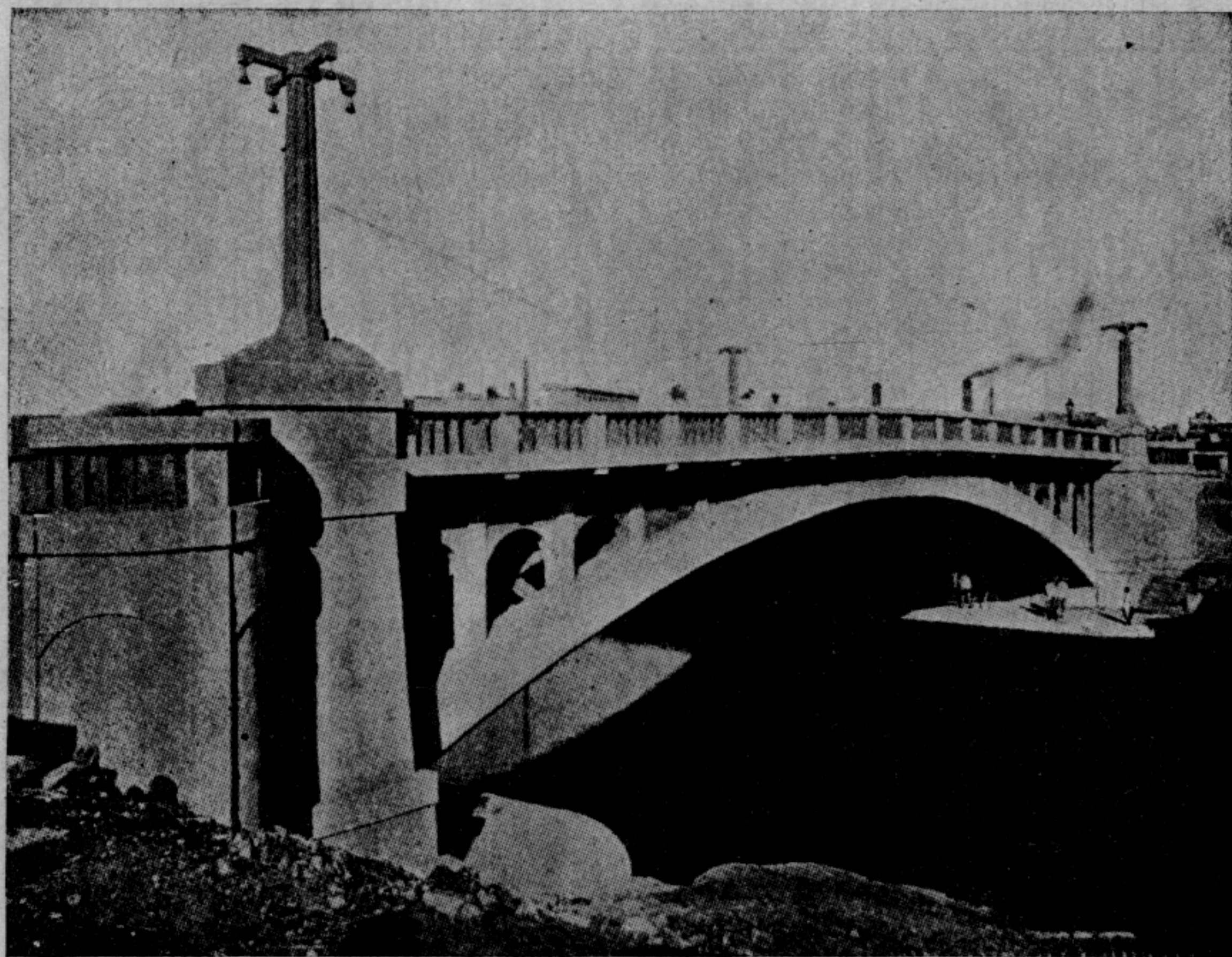


Plate 17.

Manicktola Bridge.

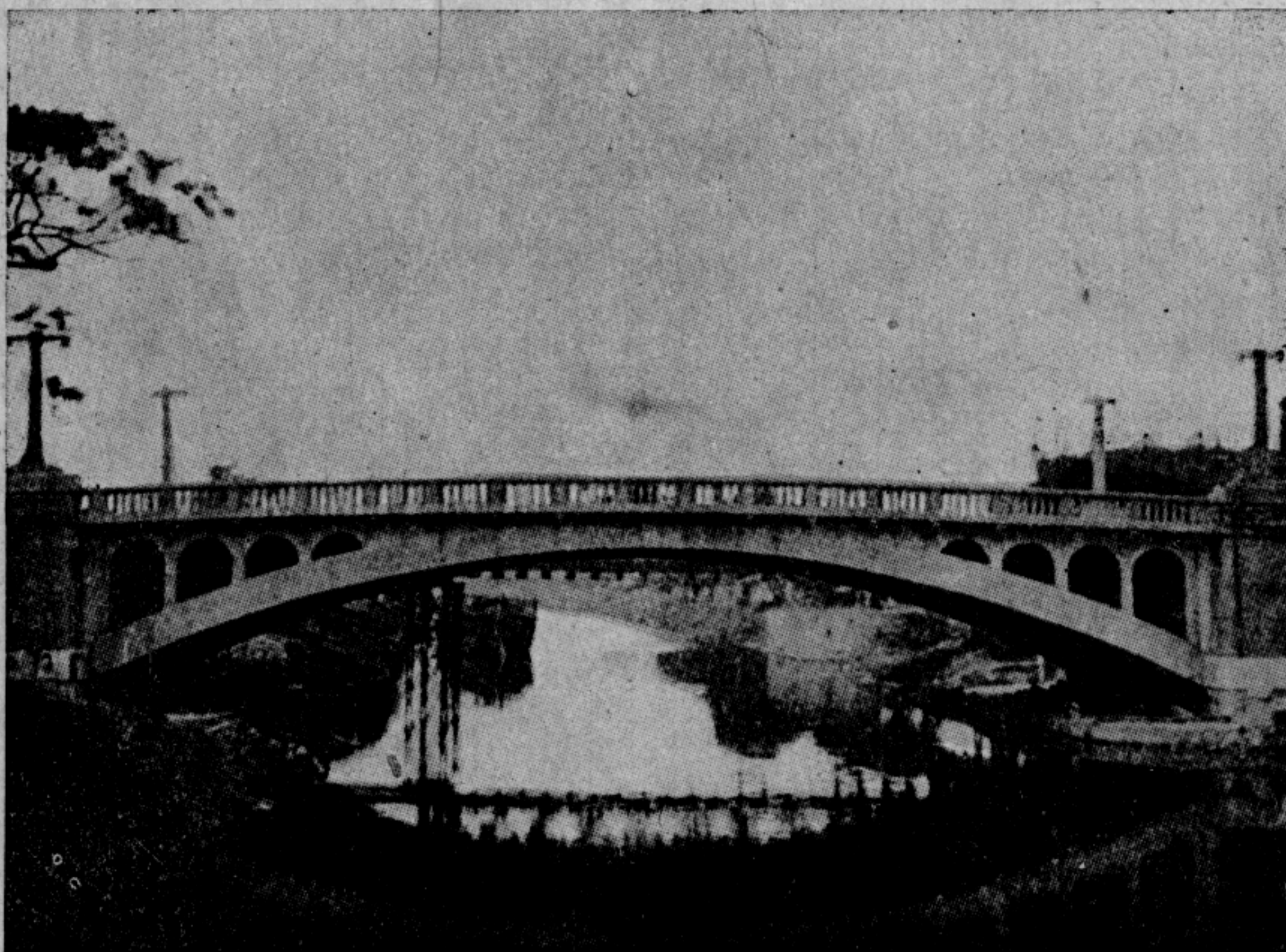


Plate 18.
Narkeldanga Bridge.

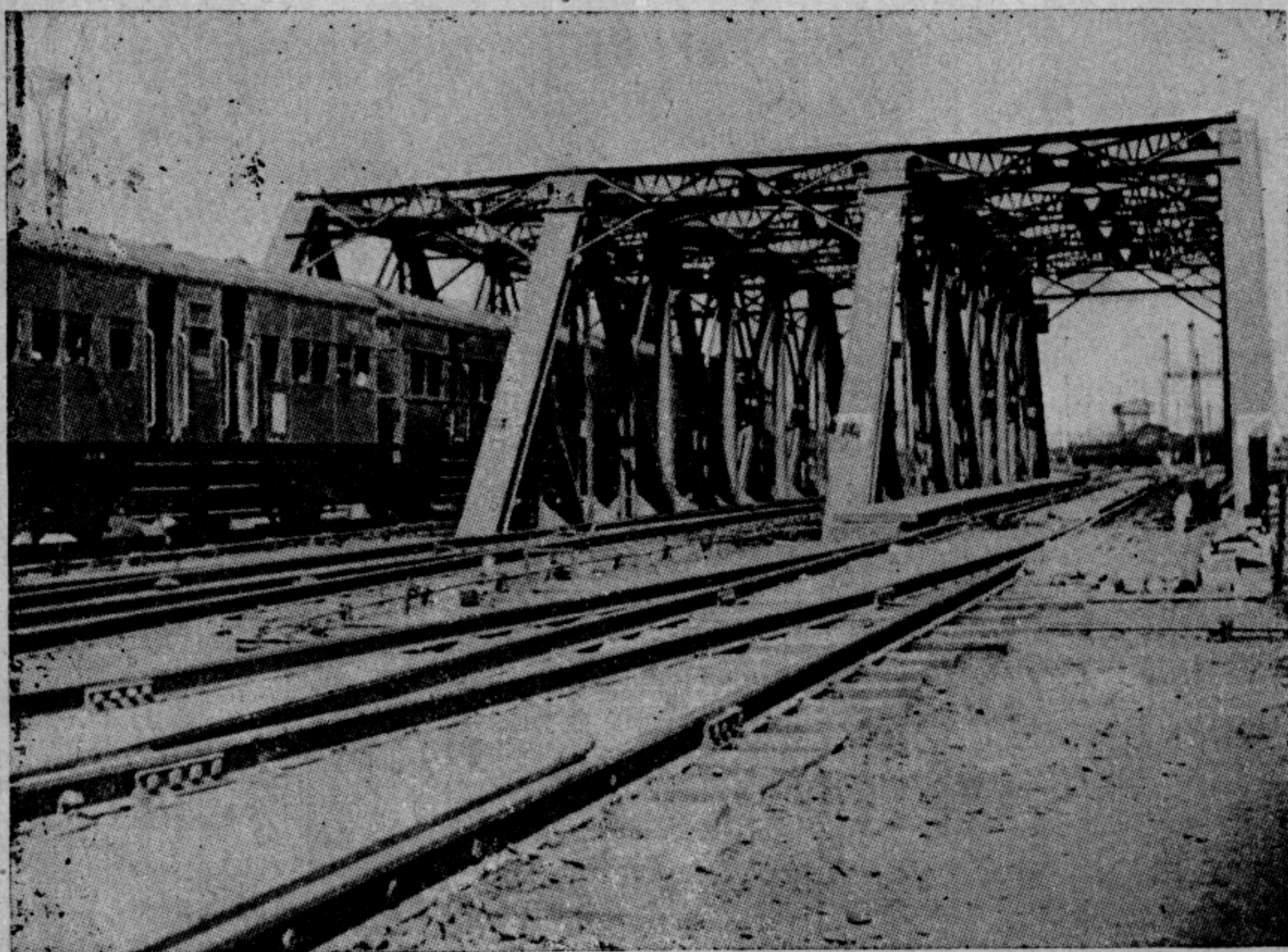


Plate 19.
Composite Pratt Truss to
accommodate three broad-
gauge railway lines sepa-
rately in one bridge.
Photo—B. Kar

small steel framed structure to carry water supply mains across the canal from Tallah Pumping Station towards Shambazar area.

4. *Belgachia Bridge*: It is located along the Belgachia Road now R. G. Kar Road across the canal very close to Carmichael Medical College now R. G. Kar Medical College. It is also an example of the reinforced concrete bridge design the principle of which is other than those of the above two. It is a reinforced concrete skew arch with filled spandrel having 128 ft effective span (centre to centre of bearing). It has 37 ft wide fast-moving traffic lanes without provision for slow-moving ones. It has side walks on either side. The approach gradient to the bridge is one in thirty-eight (1 : 38). The cost of construction was nearly Rs. 4 lakhs and 30 thousand.

5. *Ultadanga Bridge*: It was a steel framed structure which was abandoned several years ago. Vehicular traffic was suspended due to the structure being unsafe. Only in August, 1960 (19.8.60) the bridge collapsed when the workers of the

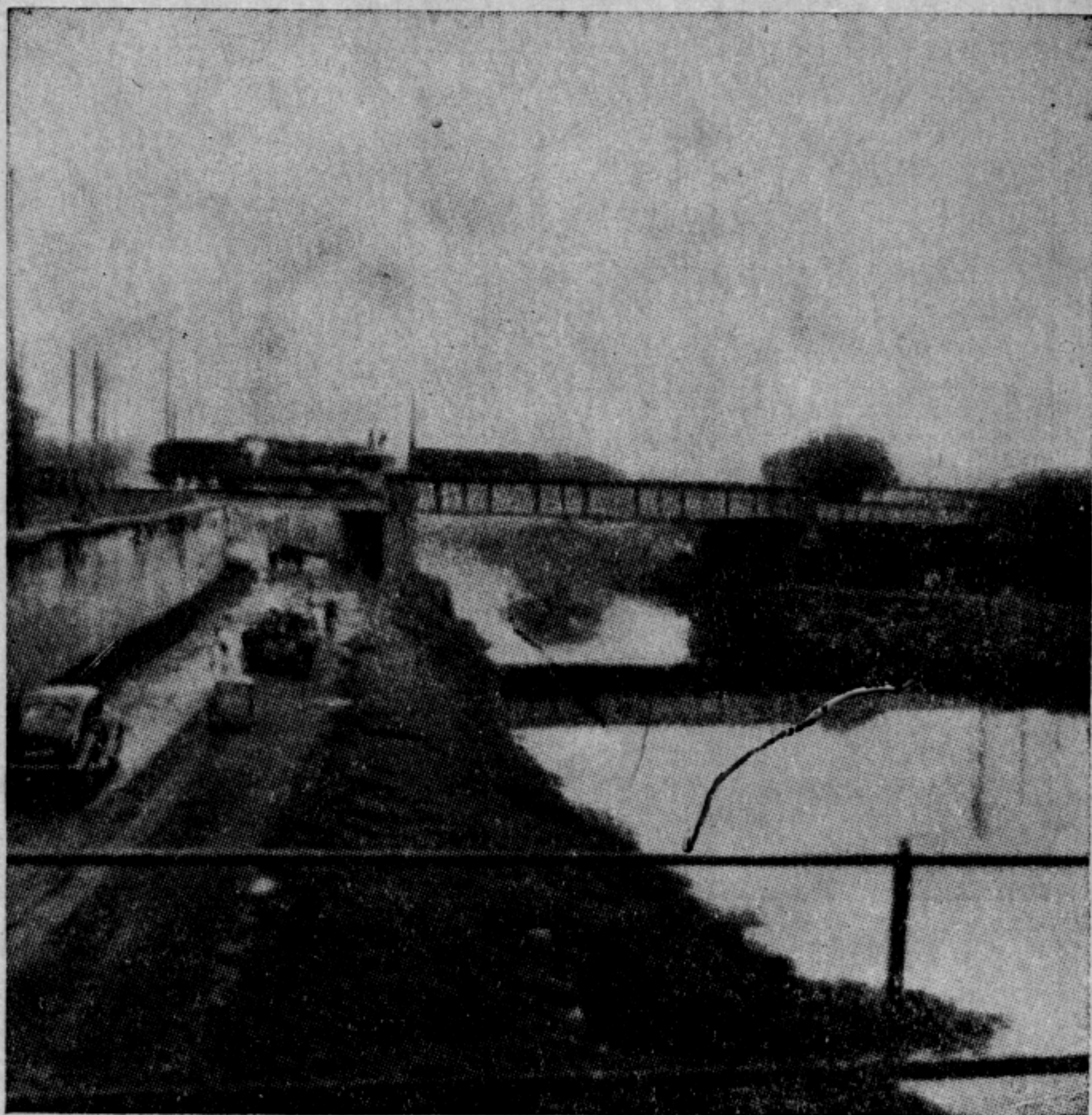


Plate 20.
Plate Girder Railway Bridge.

Photo—Author.

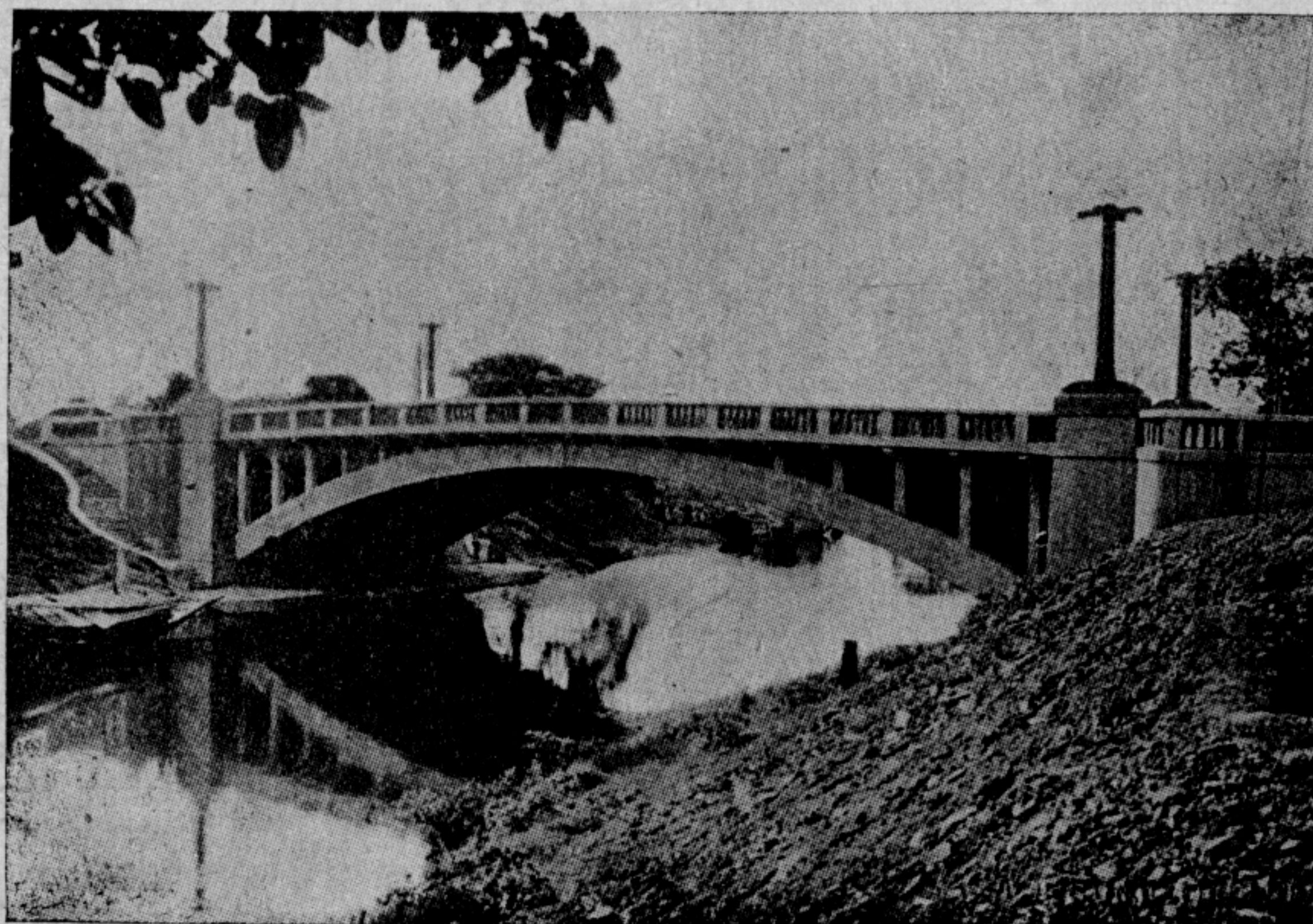


Plate 21.
Beliaghata Bridge.



Plate 22.

Railway Bridge across Bidyadhari Khal (Beliaghata Canal).

Photo—Author



Plate 23.

Road Bridge across New Cut Canal near Ultadanga.

Photo—T. Chandra

contractor were dismantling the bridge to recover some salvage materials purchased in an auction. To alleviate the difficulties of the people of the locality two Sal Bullah temporary bridges have been constructed. Because of the longstanding proposal of filling the portion of the Circular Canal beyond its junction with the New Cut Canal, construction of no new bridge has been undertaken. In that case there will be no utility of bridges to be constructed across the canal which will be converted into a road.

6. *Manicktola Bridge* : This bridge is situated on the extension of Manicktola Road (a portion of which is now named Vivekananda Road) across the canal to join Manicktola Main Road. It is also an example of an R. C. arch bridge with three hinges. It is a reinforced concrete ribbed skew arch (braced) of 128 ft effective span with provision for 37 ft wide clear fast-moving carriage-ways. It is provided on either side with two 10 ft wide footpaths for pedestrian traffic. For every 35 ft horizontal travel there is a rise of one foot along its approach. The cost of construction was nearly Rs. 6 lakhs. There is an arrangement for segregation of slow-moving traffic over this bridge.

7. *Narkeldanga Bridge* : It is situated on the Narkeldanga Main Road across the Circular Canal. It is also a reinforced concrete ribbed arch bridge (with three hinges) of 128 ft between centres of end pins. It is exactly of the same span as Manicktola Bridge. Only the clear carriage-way scheduled for fast-moving traffic is 36 ft wide i.e. 1 ft less than the previous one. It is also provided with a side footpath of 10 ft width on each side. The shore side approach to the bridge

is inclined 1 in 38. The cost of construction was just over Rs. 5 lakhs and 25 thousand.

8. *Railway bridges near Sealdah Station*: There are two adjacent sets of bridges on the main line of Sealdah Section of Eastern Railway. They are through type three-track bridges designed on the principle of Baltimore Truss and through type plate girders to carry three broadgauge tracks across the canal. Side roads along the canal pass underneath short side spans of the standard plate girder bridges used in railways.

(a) The large three-track railway bridge for the Eastern Bengal State Railway (now Eastern Railway) was erected nearly 500 yards outside Sealdah Station spanning the Circular Canal. A serious problem had to be solved by bringing about a compromise between maintaining a fixed rail level and at the same time giving sufficient headroom for canal barges to pass underneath.) This bridge, an example of Baltimore Truss type, is built on the skew of $4'-10\frac{1}{2}"$ in $55'-6"$. The effective span of the main girder is $117'-0"$ and the overall depth of the four main girders is $22'-9\frac{3}{4}"$ having an overall length of 120 ft each. The maximum depth of the closely placed cross-girders was fixed at 22 inches. These four girders, built in six $19'-6"$ panels with intermediate suspenders, are spaced at $9'-9"$ centres. Centre to centre the distance between consecutive main girders is $18'-6"$ making a total width of $55'-6"$ between outside girders. There are 33 cross-girders, 11 for each through span, the rolled steel section being $18" \times 7"$ @ 75 lb per rft. joist with two top and bottom plates, these cross-girders being secured to the main girder bottom booms with strong angles

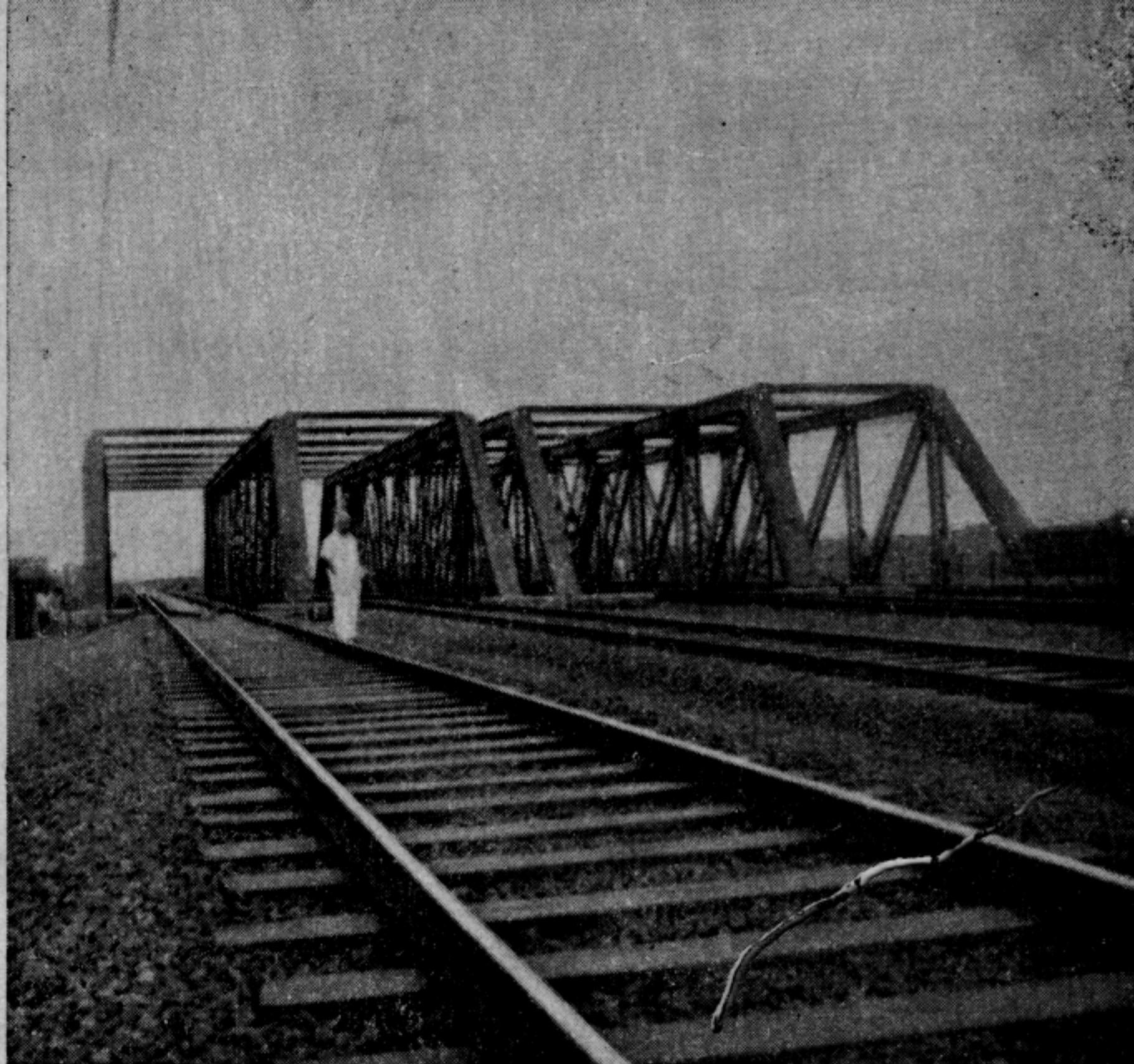


Plate 24.

Front view of the Main Line Bridge across New Cut Canal spanning the New Cut Canal in an inclined position.

Photo—T. Chandra.



Plate 25.

Side view of the Main Line Railway Bridge.

Photo—T. Chandra.



Plate 26.

Bagmari Bridge across New Cut Canal near its junction with Krishnapur Khal and very close to Ultadanga Bus Terminus.

Photo—Author,

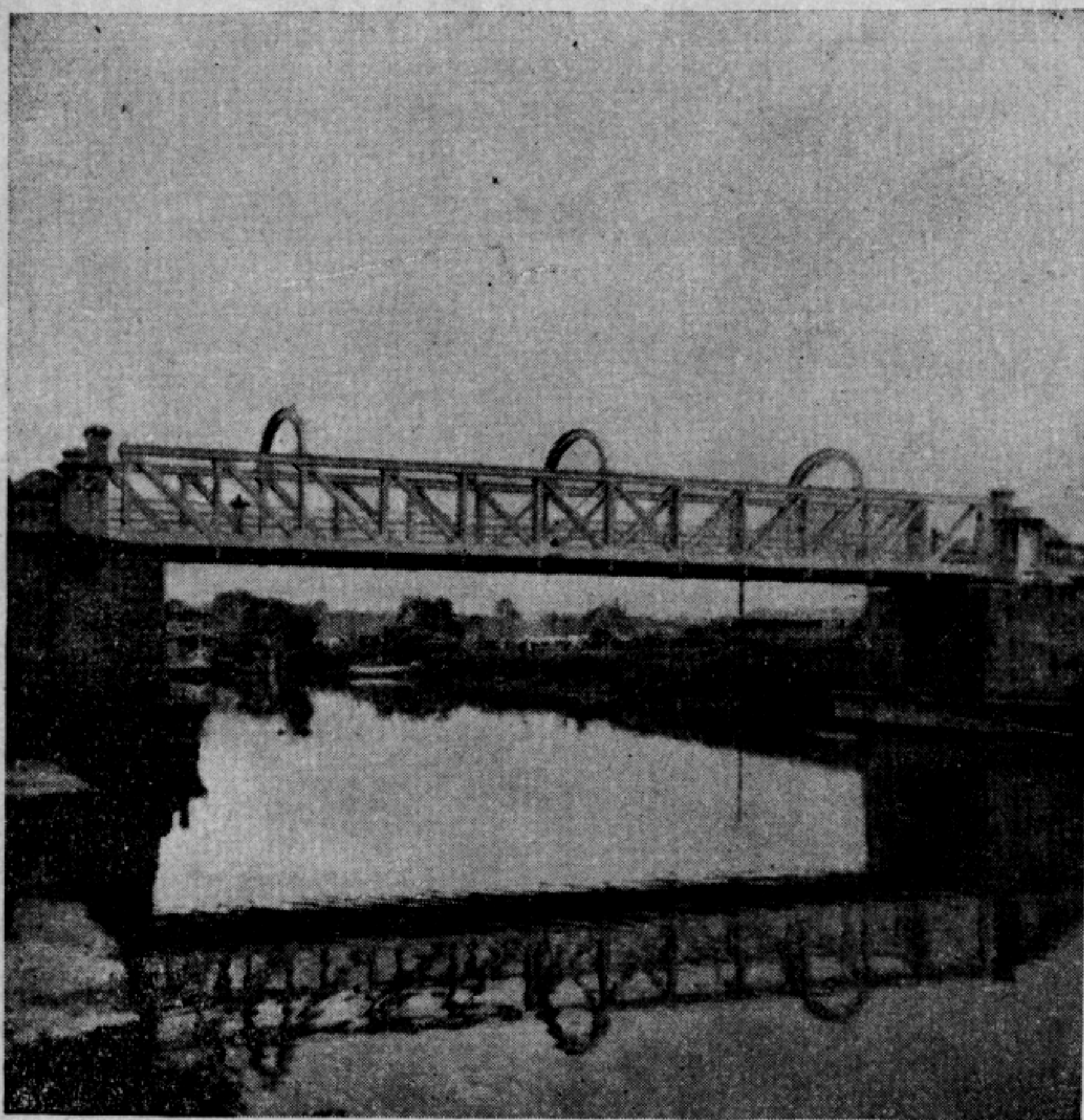


Plate 27.

Side view of the Bagmari Bridge.

Photo—T. Chandra.

through the web of joists, and substantially plated brackets on top flange rivetted to main verticals of girders. The rail bearers are 9'-9" long and are composed of 16" x 6" x 62 lb joists securely cleated into cross-girders. At the abutment ends, special rail bearers had to be provided to take the varying spans, due to the skew, a total number of 72 rail bearers being in the bridge. Curved floor plates $\frac{1}{4}$ " thick are placed between the rail bearers throughout the span, the same being connected by 3" x 3" x $\frac{3}{8}$ " through angles rivetted to webs of rail bearers. Tie-bars 4" x 3" x $\frac{3}{8}$ " section, spaced about 3'-3" centres, are fixed between rail bearers and main girders, on both sides of all tracks, to support timber footways for platelayers. These tie-bars, buckled plates, cross-girders and rail bearers combined, make a strong and compact set of bottom bracing in themselves. (The total weight of the steel-work of the bridge is about 323 tons.)

(b) To accommodate three broadgauge tracks just adjacent to the three-track composite bridge there are six plate girders to carry three main lines, two for each track. (It is a half-through type deep plate girder manufactured by one local Indian firm during 1913.) There are five splice joints for each plate girder for easy handling and transportation. The splicing of the girders helps in the erection; of course, they will need some field rivetting.

9. *Beliaghata Bridge*: It is also an example of a reinforced concrete arch bridge across the Circular Canal on the Beliaghata Main Road. It is provided with three hinges and spans 128'-0" between centres of end pins with clear vehicular trafficway

Plate 28.
Steel Arch Foot Bridge.
Photo in 1936—Author

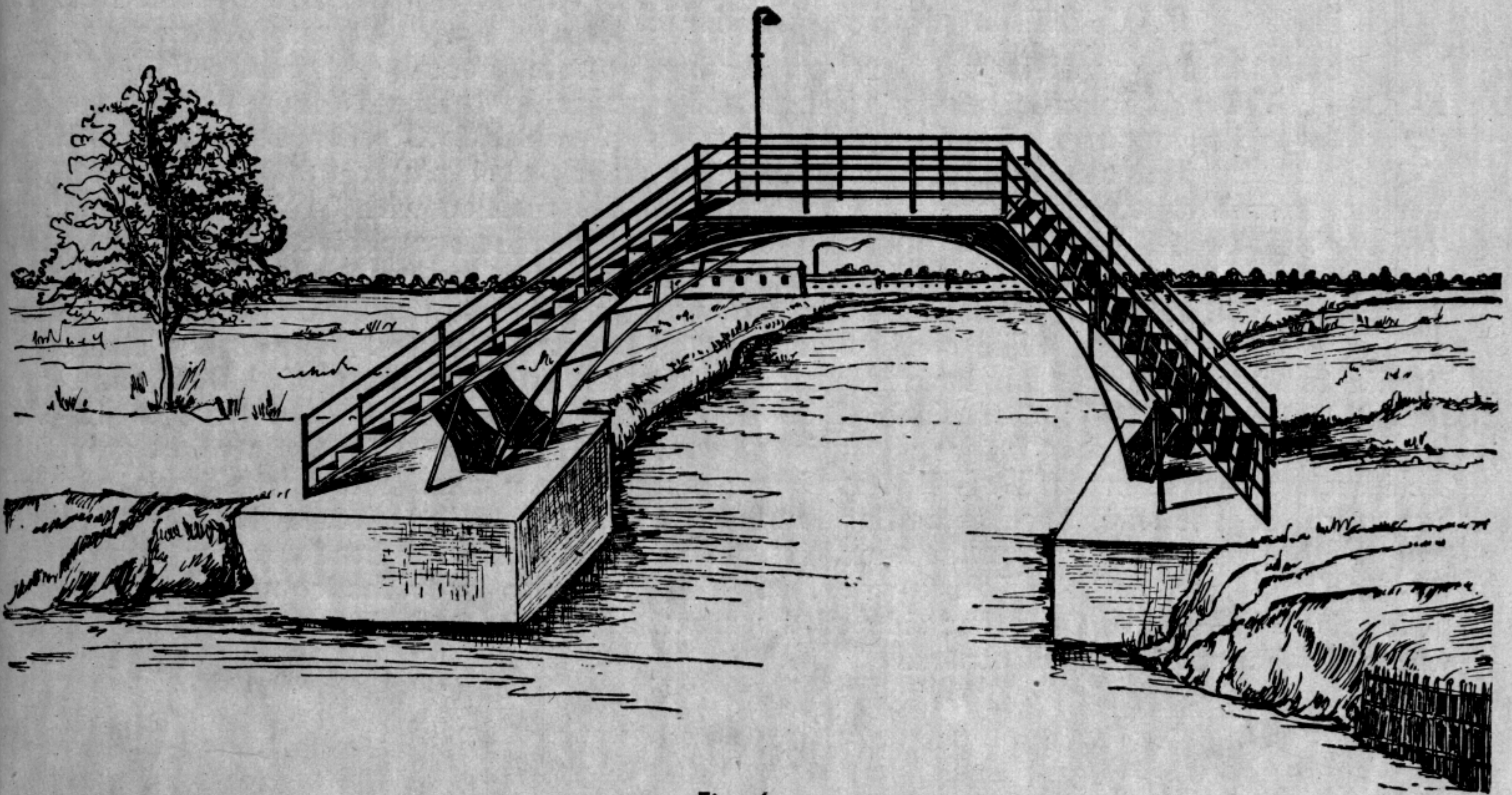
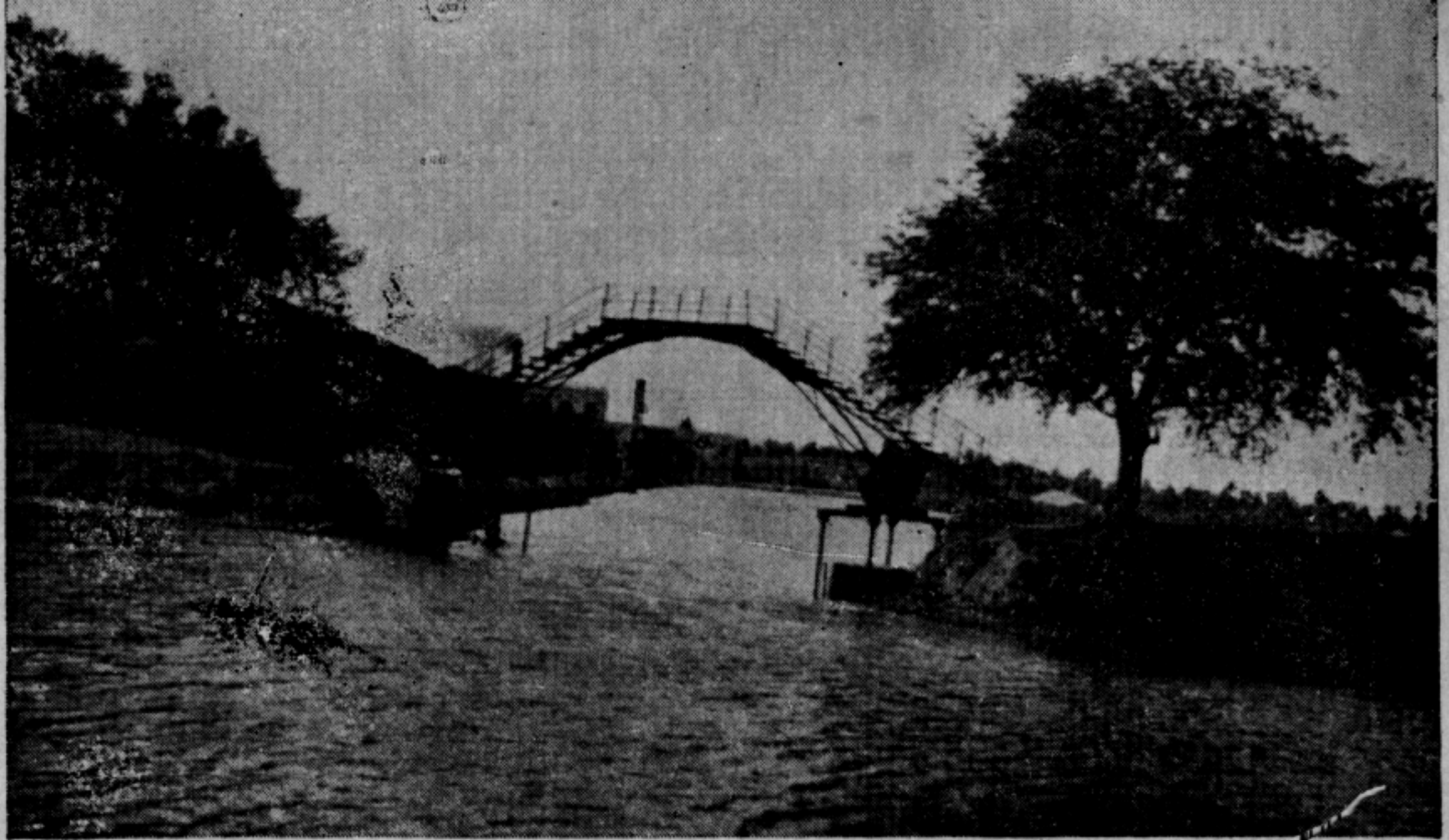


Fig. 4.
Steel Arch Foot Bridge.

of 37'-0" and two 10 ft wide footpaths. It is just a copy of Manicktola Bridge regarding span, road width and shape of the bridge. It was constructed by Messrs Bird & Co. Ltd.

10. *A railway bridge across Beliaghata Canal:* It is a steel framed structure which joins the northern and southern sections of the Eastern Railway (Sealdah Section), bypassing

Sealdah Station. The bridge is a N-type Pratt Truss which spans the Beliaghata Canal. It consists of two separate bridges to carry two independent broadgauge lines. This portion of the canal was popularly known as Bidyadhari Khal. This bridge was constructed by the Motherwell Bridge Co. Ltd., Motherwell in 1908.)

Across the New Cut Canal which emerges from Circular Canal near Ultadanga, there are three bridges.

11. *A road bridge just at the mouth of New Cut Canal near Ultadanga:* It spans the New Cut Canal to carry the road (Canal East Road) along the Circular Canal along its eastern side. It is a steel framed N-type Pratt Truss with five vertical members having roadway for both fast and slow-moving traffic. It has two independent footpaths along its side having sufficient clearance to take steamers, boats and launches to Krishnapur and Bhangar and other places where there was no suitable all-weather road in the past.)

12. *Main line railway bridges (near Gurudas Dutta Garden Lane):* They are composed of two sets of composite girders to accommodate four broadgauge tracks on the main line. They are placed in skew due to the obvious reason of the location of the New Cut Canal not being at right angles to the axis of the railway tracks. Two sets of through type twin latticed steel structures composing the bridges have clear headways of 16'-4½", 16'-6", 16'-5" and 16'-6" respectively when measured from east end of the sets of twin trusses. Steelworks of these bridges were manufactured by Messrs Bridge and Roof Co. (India) Ltd. in 1940 replacing the old girder bridge.

13. *Bagmari Bridge near Lansdowne Jute Mill:* This is a foot bridge placed at a high level for easy movement of the river craft underneath without any obstruction.) It is a single simple span N-type structure having bottom boom composed of 1'-3" × 1", 1'-3" × 7/8", 1'-3" × 1/2" parallel plates of gradually reducing thickness from the centre of the span to its supports. The top boom consists of two 10" × 3" channel sections placed 1'-3" apart having top portions connected by mild steel plates of the same width. Vertical members are composed of four 5" × 3" angles rivetted with 1/2" wide M. S. plates to form built-up I-Section. Bottom ends of vertical members are rivetted with built-up cross beams by means of suitable cleats to carry the road. Cross bracings are of flat bars of different width varying from the wider section at the centre to the narrower section at the supports. The road is constructed on steel troughs. The bridge structure simply rests on four steel base plates. It has an effective span of 110'-6", and an overall length of 113'-6"; clear width of the road is 16'-0". The depth of the truss is 10'-1".

14. *Steel arch foot bridge:* It is a wonderful example of a rickety but graceful steel arch bridge composed of light steel angles and thin plates. Along the back of the curvature of the arch an ascending and descending steel staircase is incorporated having a horizontal landing on the apex. It not only provides clear headway for barges to go into the moat of the Lansdowne Jute Mill but also provides communication for pedestrians to go to the other side of the moat. It is situated close to the road bridge where Krishnapur Canal bifurcates.

Bridges across Tolly's Nullah and within Lake area

The most intricate problem of layout of a bridge structure is not only basically economic but it deserves consideration of the various aspects which have no direct bearing on the question of costs. The general idea is that a structure with a minimum initial capital cost is the best possible layout. It is far from truth. In consideration of layout of a bridge structure with suitable grades of approach, with suitable clearances, spanlengths, graceful appearance of superstructures and character of substructures the possible items intended to cover all aspects (only a few may apply to any specific case) are listed below. In Chapter II types of bridges in relation to spans have been exhaustively dealt with. The factors and conditions that influence the layout of bridges are stated below :

- f (i) Whether it is a road or railway bridge having footpaths for pedestrians; whether it is a single or double track railway bridge; how much clear width of road will be provided, etc.
- (ii) Grade of approach in relation to alignment.
- (iii) Geographical condition of the locality.
- (iv) Geological features for foundation consideration; whether located in seismic region or not.
- (v) Class of structure—e.g. Plate Girder Spans on Piers or on Trestle, Latticed Girder or Pin Jointed Truss on Piers, or on Trestle, Cantilever Structure, Suspension Bridge or Draw-Spans, etc., etc.
- (vi) Scope of future enlargement.
- (vii) Stream consideration, whether perennial or seasonal, etc.
- (viii) Navigability of the watercourses—(throughout the year or during rainy season)—for which suitable clearances for ocean-going ships to pass under has to be provided.
- (ix) Consideration for erection facilities for equipment, construction of false-works, cable running or floatation and for maintenance of traffic has to be made.

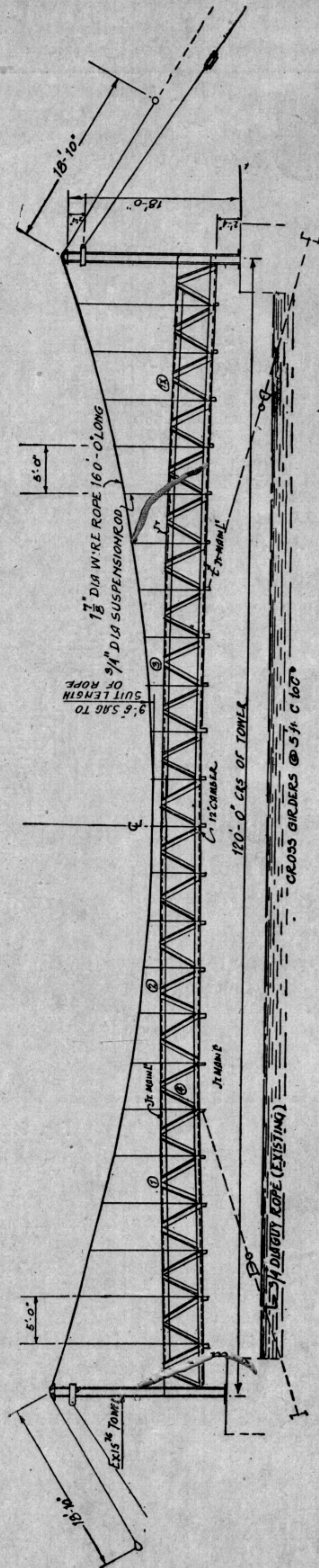


Fig. 5.
The Suspension Bridge of Calcutta.

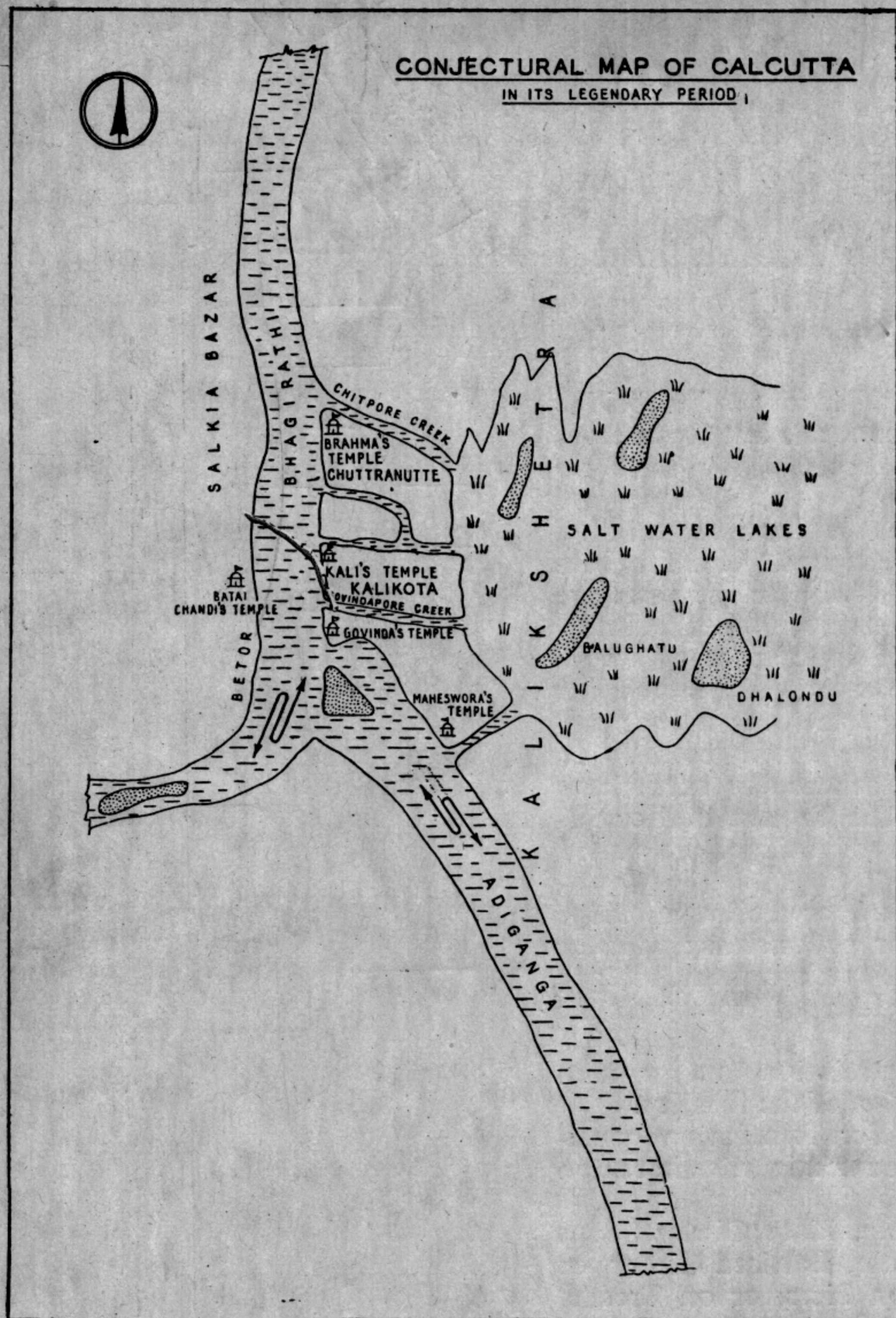


Fig. 6.

concurrence of various Government Departments, Federal or State or local for the undertaking of the work e.g. Irrigation and Waterways Department, Port Authorities, Railway Authorities, Public Health Engineering Department, Municipal Corporation (if the works undertaken happen to be within the city limits), Roads Department, Central Public Works Department, if the project affects foreshore land, etc. to fulfil their requirements.

(xvii) Cost of general maintenance and repairs.

- (x) Foundation consideration for the whole area of crossing by digging trial pits or making borings as may be needed. If the footing are to be founded on rocks its geological characteristics, dip of strata, hardness, friability, influence of exposure to weather, should be ascertained. Similar details of foundation on clay, sand or gravel or their mixture, or on different types of piles should be ascertained.
- (xi) Aesthetics of structure which is determined by its graceful appearance in relation to environment.
- (xii) Consideration of time for completion of works.
- (xiii) Consideration of property to be affected by the project.
- (xiv) Its influence on commerce by the construction of the proposed structure for communication.
- (xv) Availability of construction materials at bridge site e.g. sand, gravel, coarse aggregates for concrete works, machine shop for repair facilities, proximity of railhead, means of transportation of men and materials.

(xvi) Legal obligations :

(xviii) Availability of residential facilities to staff and labour in the neighbourhood of site of works.

(xix) Availability of pure and wholesome water, of suitable place for disposal of sewage, and of medical facilities for quick medical attendance.

(xx) Economics.

One of the renowned bridge engineers the world has ever seen opines that "the truly economic bridge is the one for which the sum of the first cost and the capitalised annual cost of operation, maintenance and repairs is a minimum".

Sometimes conflict arises between aesthetics and economy in which case a comparison has to be made and also in relation to all the above aspects a suitable and happy compromise has to be evolved to come to a wise decision.

Bridges across Tolly's Nullah from its confluence with the river Bhagirathi or Hooghly

One of the most important canals of Twenty-four Parganas is Tolly's Nullah which connects the Hooghly with the Bidyadhari. It covers a length of ten miles. It was excavated in 1770. In those days, steamers used to enter the Bidyadhari through the Tolly's Nullah and take the Sundarban route via Port Canning and Matla. But owing to deterioration of the Bidyadhari and Matla, the steamer route was abandoned.

15. *The vertical lift bridge* : Exactly similar to the vertical lift draw bridge on the mouth of Circular Canal, there exists a steel framed structure from which the rail-bearing structure is suspended by

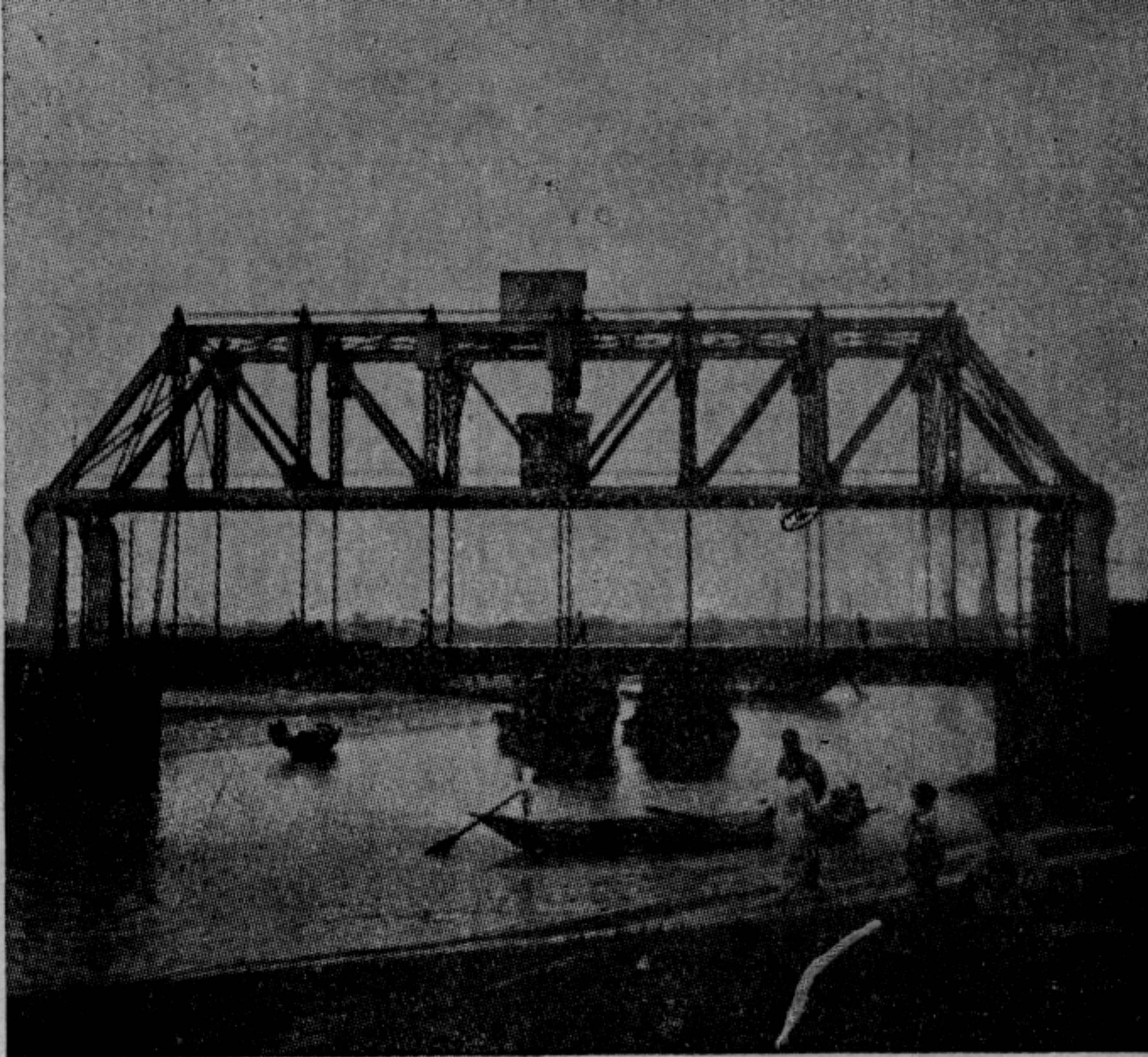


Plate 29.

Vertical Lift Bridge across Tolly's Nullah.

Photo—Author.



Plate 30.

Hastings Bridge across Tolly's Nullah within 100 yds of vertical Lift Bridge.

Photo—Author.

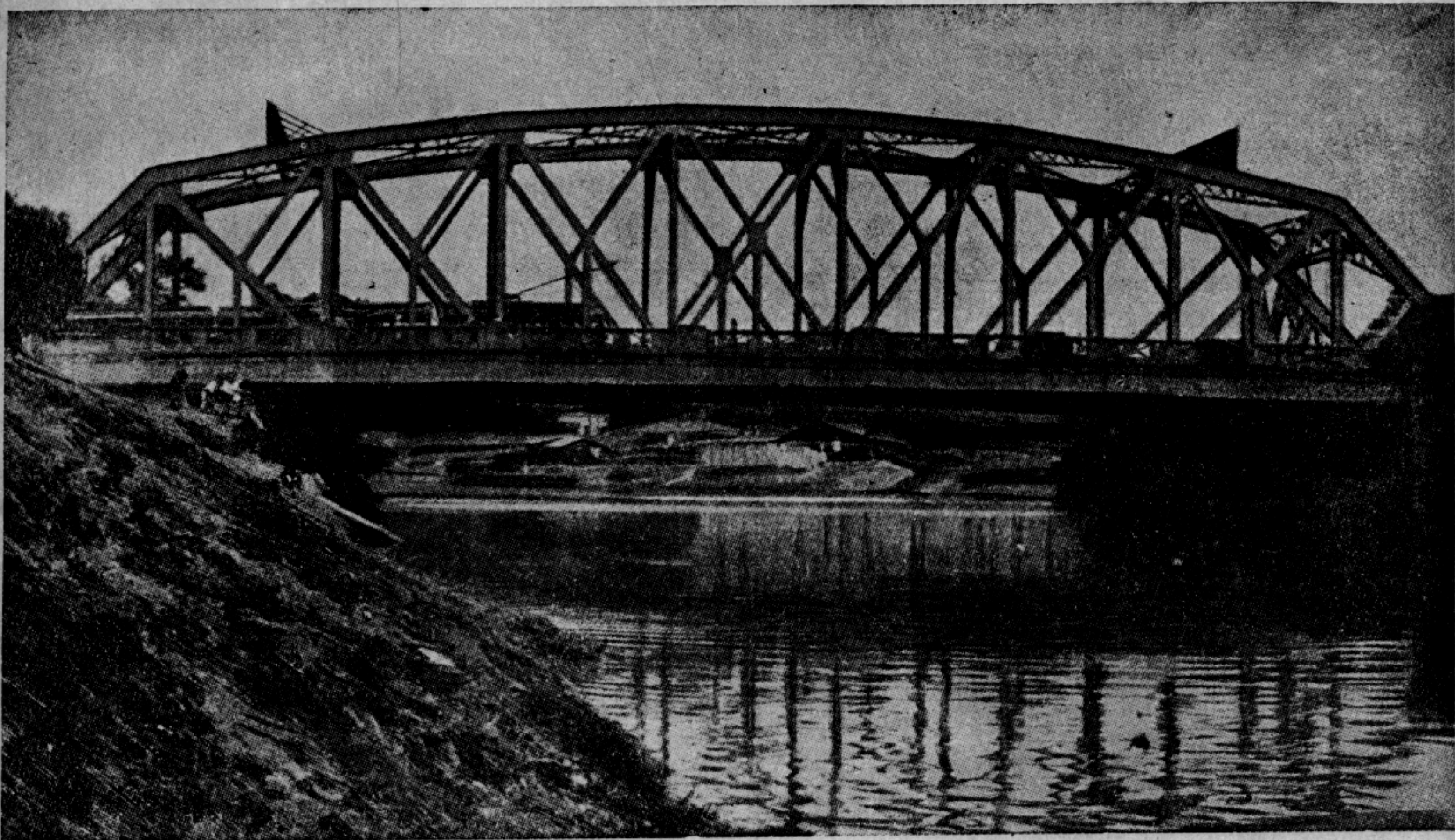


Plate 31.
Khidderpore Bridge across Tolly's Nullah.

Photo—B. Kar.

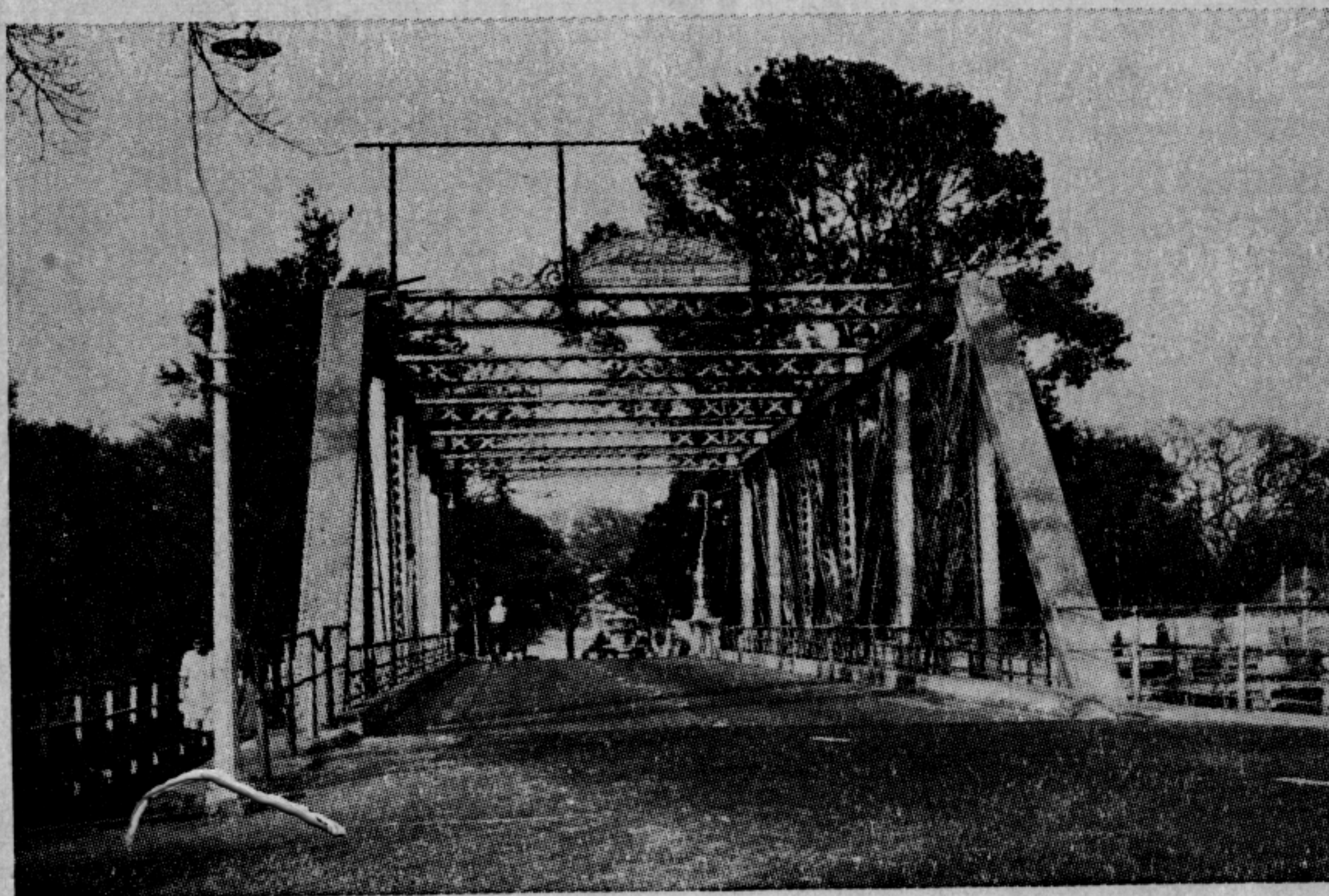


Plate 32.
Zeerut Bridge across
Tolly's Nullah.

means of a series of M.S. rounds-cum-steel wires. The upper ends of the suspension rods are tied with one end of the individual wire ropes which pass over the grooved pulleys and carry counterweights at other ends. Pulleys on each side are connected with two common horizontal shafts running over the two top beams of the framed structure. Two parallel shafts have two bevelled gears. These two bevelled gears are connected by another two bevelled gears connected at two ends of a shaft which has a toothed gear fixed almost at the middle. The central toothed gear is connected with the toothed gear shaft of the electric motor which vertically lifts the structure uniformly and smoothly. There are profusely greased four vertical guide rails fixed on the raised steel framed abutments to control the vertical liftings without any oscillation or vibration so as to allow the river craft to pass without obstruction. (At that time Port Commissioners' rail traffic is temporarily suspended.) The fixed structure has an effective span of 120 ft. The suspended structure consists of 2'-9" deep plate girder connected with transverse girder of 3'-2" deep through ends of which the threaded suspender rods pass. The total length of the suspended structures is 111 ft having the width of 17'-0". It carries single line broad gauge railway track. The distance between bottom of the fixed structure to the top of the suspended structure is 18'-0". There are two engaging pins on the abutment walls which will indicate the correct resting position of the suspended structure to allow the railway wagons to pass over it. (The bridge was constructed by one of the engineering firms of Howrah.)

16. *Hastings Bridge*: It is a

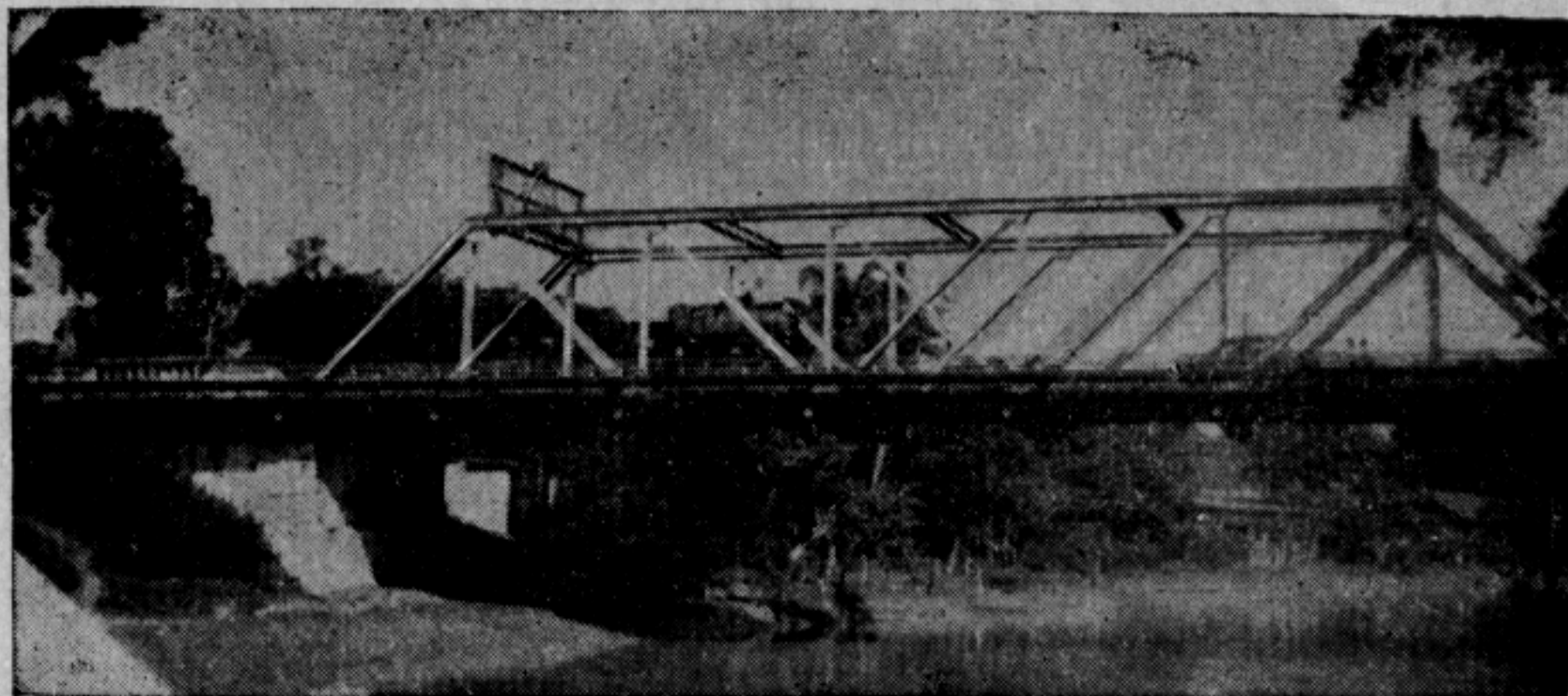


Plate 33.

Side view of Zeerut Bridge.

Photo—Author

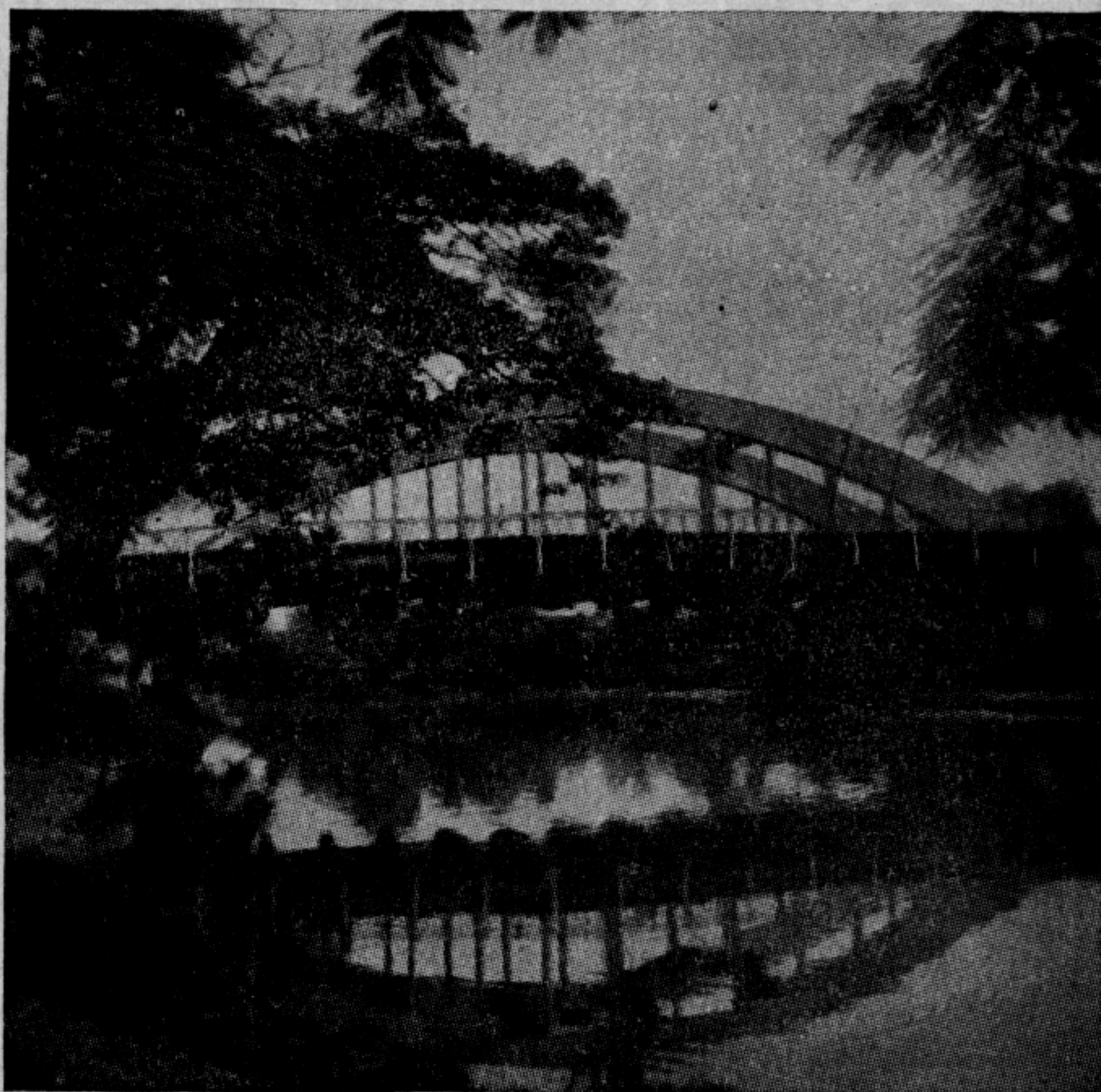


Plate 34.

Side view of Alipore Bridge across Tolly's Nullah.

Photo—Author.

steel framed structure built up of series of closely placed channels and numerous thick flat bars inclined at suitable angles and rivetted with each other to constitute the web portion of the latticed girder. The floor of the bridge is of reinforced concrete slab which rests on a series of horizontally placed heavy section rolled steel joists suspended by means of bolts

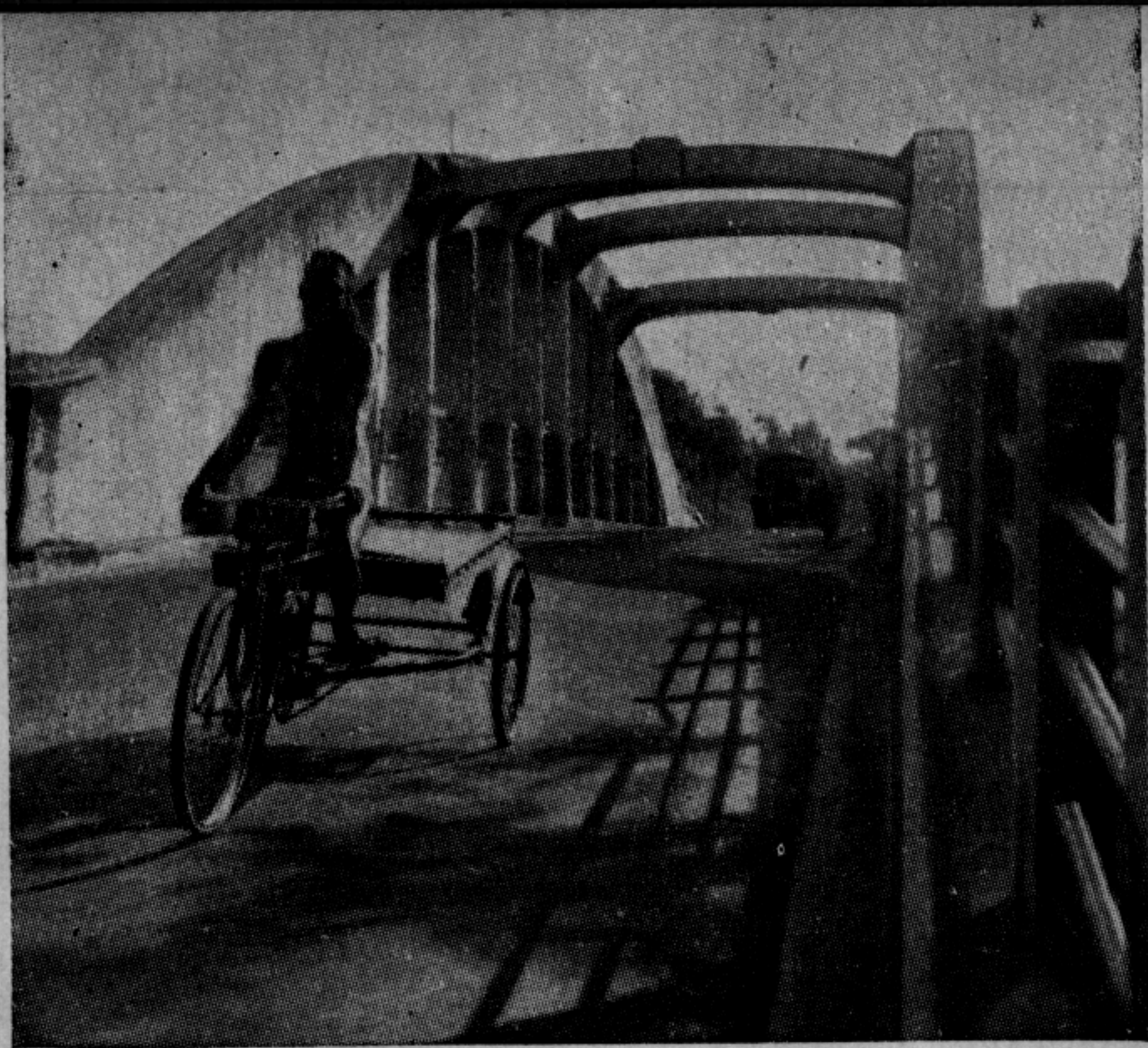


Plate 35.
Front view of Alipore Bridge. Photo—Author



Plate 36.
A view of Kalighat Bridge across Tolly's Nullah.
Photo—G. Modak.

and nuts from underneath the framed bridge structure. They do not rest on the bottom beam of the main structure. Fixing bolts are mostly in tension. There is provision of a narrow footpath on the western side of the bridge only within the bridge structure whereas on the eastern side there is no such provision.

17. (*Khidderpore Bridge* : It is a big and spacious steel framed structure to carry two lines of tram cars and roads for fast-moving vehicular traffic.) On the outer side of steel trusses, stone paved roads to carry slow-moving bullock and hand carts are laid.) Beyond slow-moving traffic lanes there are footpaths on either side of the bridge at a little higher level. Both slow-moving traffic lanes of 7'-8" each and pedestrian footpaths of 13'-2" rest on two cantilever portions across the main bridge structure. It was manufactured by a local firm in their Girder shop. The clear span of the bridge is 229' having 35'-3" wide fast traffic lane. The approach road has an inclination of one in fifty to one in fifty-five.

18. *Zeerut Bridge* : It spans the Tolly's Nullah and carries a road leading to the Zoological Garden and Belvedere previously used as Viceregal Lodge in Calcutta. The National Library has been housed in that historic building.) The bridge is a pleasing example of a steel framed structure of bygone days. (Its sound design, graceful appearance and fine finish wonderfully fit in with the natural environment of the locality. It is an admirable example of utility and beauty intelligently amalgamated in relation to their importance. Though originally constructed in 1854 by Messrs Burn & Company Ltd. it had got to be rebuilt in 1904. The present bridge is still standing the test of time though

Plate 37.
Kalighat Bridge across
Tolly's Nullah.
Photo—B. Kar.



another half a century has already elapsed. Is it not high time to ask the same engineering firm to replace the same with a more beautiful one? But even hundred years is not a very long time for the replacement of a really good bridge structure, if properly maintained.

19. *Alipore Bridge (on Bhowanipore Road)*: It has a road width of 30'-0" for movement of traffic without any arrangement for separation between slow and fast-moving ones. It carries footpaths 8'-0" wide on either side. It has a maximum grade of approach of one in thirty-five (1:35). The cost of construction in 1932 was nearly Rs. 3 lakhs. This is a reinforced concrete bowstring girder bridge having footpath on each side at a considerably higher level to accommodate steel water mains of the Calcutta Corporation on the cantilever arms of the structure. Adjacent to the bridge are Government quarters and Bhowanipore Burial Ground which may be observed by one when proceeding towards Maidan end.

20. *Kalighat Bridge*: It carries also tram lines leading to Alipore Judge's Court from Kalighat side. Due to the narrowness of the bridge two-way traffic flow cannot be maintained. It is a positive bottleneck for smooth traffic flow. It carries both up and down tram lines partially overlapping each other so that trams from only one direction can pass at a time. So also the vehicular traffic can pass with green signal light for unidirectional movement. It is provided with two independent footpaths for pedestrians. Kalighat Bridge is an example of a mild steel bridge having a span of 110 ft and width of 22'-10" from centre to centre of main girders. Each main girder has on its outer side footpaths resting on cantilever arms making the total width of the bridge 35 ft. As it is intended to carry the tram line, heavier section floor beams have been provided. The total weight of the steelwork is 120 tons nearly. This bridge was fabricated in Messrs Burn & Co.'s Girder Shop at Howrah.

(There is one temporary coal-tar painted wooden bridge which has not been brought under our consideration for the book and consequently not numbered. It rests on Salbullah piles and framework.)

21. *Railway bridge near Kalighat station*: It is situated close to Chetla Lock of Port Commissioners' Port Canal. It is an example of fabricated steel structure resting on screw cylinder pile foundations. There are two such adjacent structures to carry independently one up and the other down railway tracks. Underneath the western approach Chetla Road passes and runs along the canal till it joins the road which passes over the Tollygunge Bridge connecting New Alipore area with Tollygunge.

22. *Tollygunge Bridge*: It is situated on Tolly's Nullah connecting Tollygunge area with New Alipore region. It is a reinforced concrete bowstring girder bridge of 110' span having clear headway of 22'-2½" with 30' wide clear carriage-ways for mixed traffic. It carries an 8'-0" wide footpath on either side. The maximum grade of approach is one in thirty-five (1:35). The cost of construction was nearly Rs. 2.5 lakhs during pre-war days.

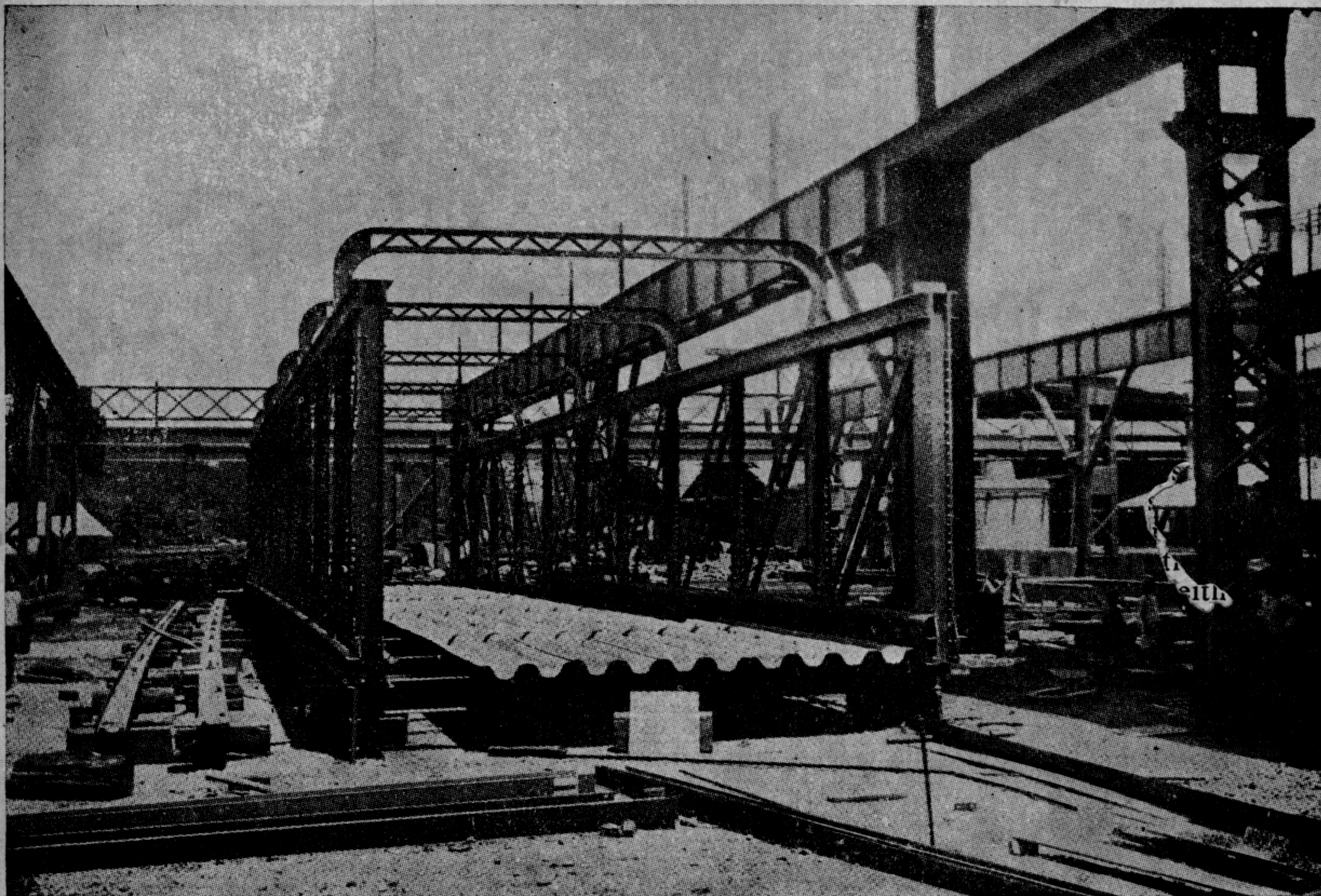


Plate 38.

Kalighat Bridge under construction in Howrah workshop of Messrs Burn & Co.

23. *Garia Road Bridge* : (It is a single span steel framed structure across Tolly's Nullah to carry road from Garia to Baruipur and further south to Jaynagar-Mazilpur. It is situated close to the bus termini of Routes No. 5 and 6 and is an example of through type Pratt Truss. Tolly's Nullah continues its circuitous journey till it connects Vidyadhari river. Two abutments are constructed at a suitable level to receive the steel structure so as to pass the river crafts without obstruction even during high flood tide.)

24. *Garia railway bridge* : (This is the last in the series of bridges to span Tolly's Nullah. It is a skew steel framed bridge to carry a single line broad gauge track of Sealdah Section of Eastern Railway. It is an N-type Pratt Truss composed of five vertical members, two inclined members and an additional inclined member to take care of the stresses due to obliquity of the structure. Two parallel trusses are constructed with portal frames. The structure rests on four roller bearings. (Railway sleepers are placed on built-up plate girder fixed on cross-girders. The steel structure was fabricated by MacLellan Limited in 1901 in their Cluthan Works in Glasgow, Scotland (under I.S.R. Contract No. A 4060).)

Lake area (Rabindra Sarobar)

{ The excavation of an artificial lake in Calcutta popularly known as Dhakuria Lake

was considered essential by the Calcutta Improvement Trust from various considerations. It has not only become an utility venture but also a beauty spot of the city. The fundamental objective is to provide earth for filling up of the low-lying marshy land of the Dhakuria area to convert it into suitable house-building plots and roads. At the same time it affords a considerable open space for parks and play-grounds for the people of various age-groups, by way of providing children's play-field with playlots, arena for organised games with stadium, strolling places for elderly people with necessary equipment like benches, shelters, lily pools, swimming pools for bathing and swimming, playing water polo and aqua theatre, etc. It also provides a sizeable open space which is necessary for the creation of an ideal neighbourhood in the vicinity and also affords a large scope for piscicultural undertakings for producing more protein food.)

(The original lake area was acquired in 1920 and subsequently it was extended in 1934 by the Calcutta Improvement Trust. The total space of the lake including parks covers an area of nearly 200 acres out of which the water area extends over 80 acres. The total cost of the scheme was Rs. 17 lakhs out of which Rs. 6 lakhs was for land acquisition and the remaining eleven lakhs is for mainly engineering and arboricultural works.)

25. *Suspension bridge*: The hall mark in the display of various types of bridges in Calcutta is the rare suspension bridge in the lake of Ballygunge. It is an example of suspension bridge of 120 ft span for allowing pedestrians to go to the island

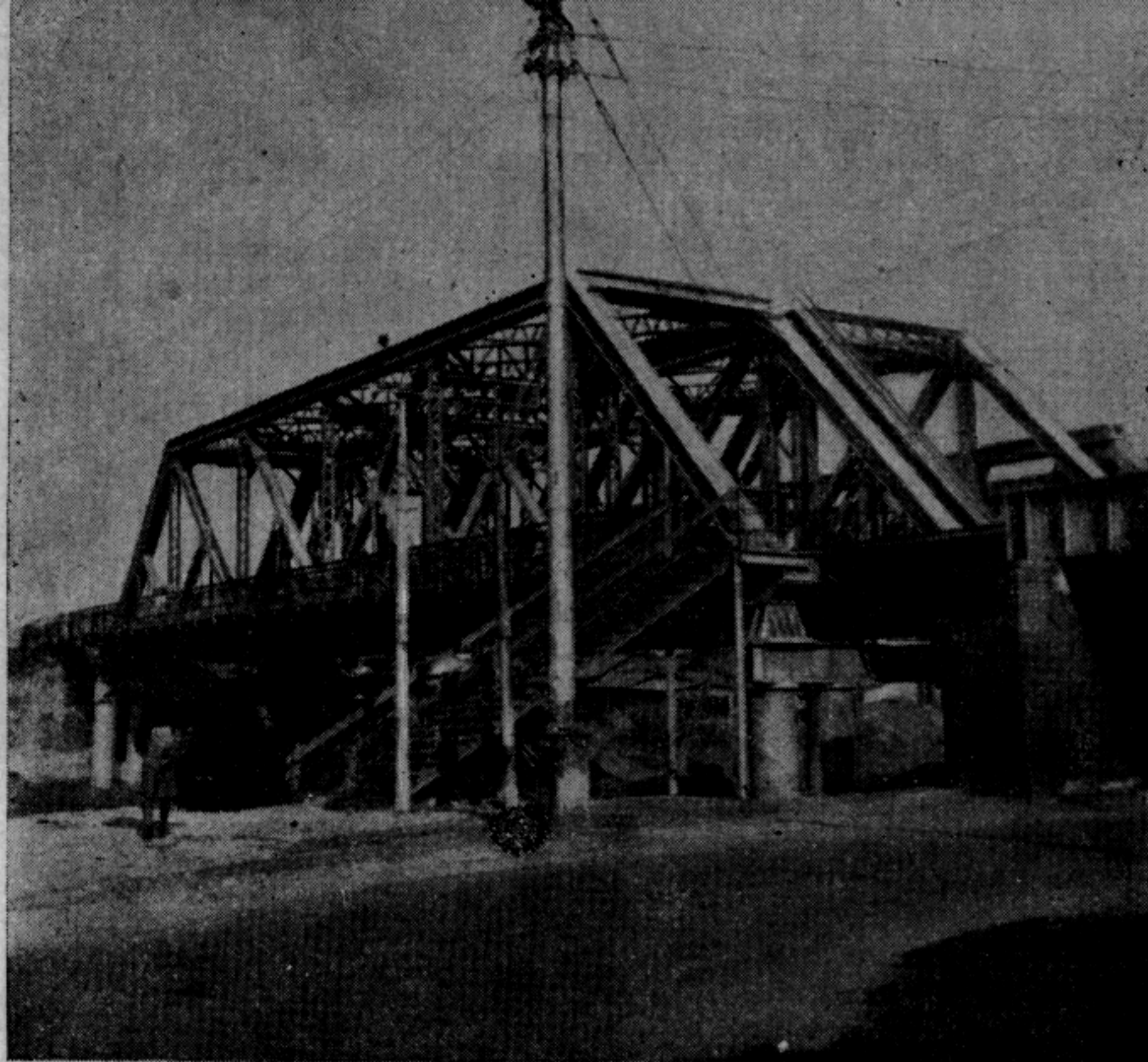


Plate 39.

A Railway Bridge close to Kalighat Rail Station across Tolly's Nullah.

Photo—Tarit Chandra.

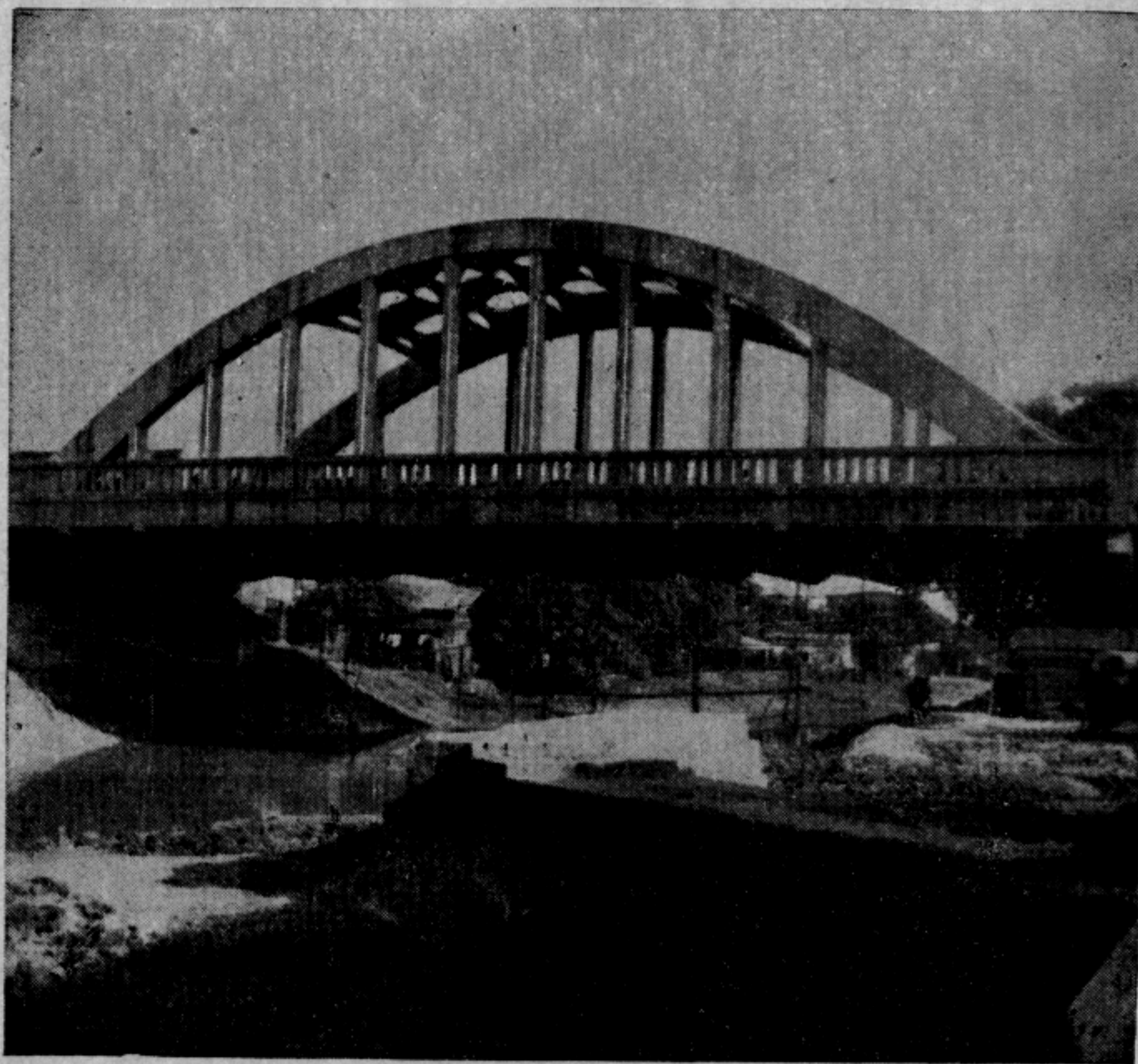


Plate 40.

Tollygunge Bridge across Tolly's Nullah.

Photo—G. Modak.



Plate 41.
Garia Road Bridge across Tolly's Nullah.

Photo—T. Chandra.

where stands a white mosque in Rabindra Sarobar (popularly known as Dhakuria Lake) from the main land. The whole structure is suspended from a pair of $1\frac{7}{8}$ " diameter wire ropes passing over two towers 18' high and the end of the steel cables are anchored at shores. The deck is only 4' wide and rests on the bottom beam of through type latticed girder. The bottom structure is suspended by $\frac{3}{4}$ " diameter rods of various approximate lengths—15'-1", 13'-1", 12'-1", 11'-1", 10'-1", 8'-7", 7'-0", 6'-7", 5'-9", 5'-3"—4 nos each and 5'-0"—2 nos. It swings considerably when many travellers pass and specifically during high wind. The fabrication was done in one of the structural engineering factories in Howrah. The same firm also erected the structure in 1926. The project of reconstruction of the bridge will soon be taken up.

26. *R. C. arch bridge over lake*: This bridge is popularly known as Dhakuria Bridge carrying the Boroz Road to the lake. It is a reinforced concrete single span arch resting on spandrel walls designed to accommodate light traffic across the lake. It was constructed without a temporary major wooden falsework. Earth was excavated in such a shape that it formed the ultimate shape of the different members of the structure. In the recess of the soil stabilised formwork supplemented with wooden planks and scantling, concrete was poured into the cage of reinforcement previously placed in correct place and position. Side shutterings wherever necessary were fixed in their correct places to retain the concrete insitu and maintain the ultimate shape. After the lapse of sufficient settling time and after necessary curing the underlying earth was gradually excavated and removed to connect

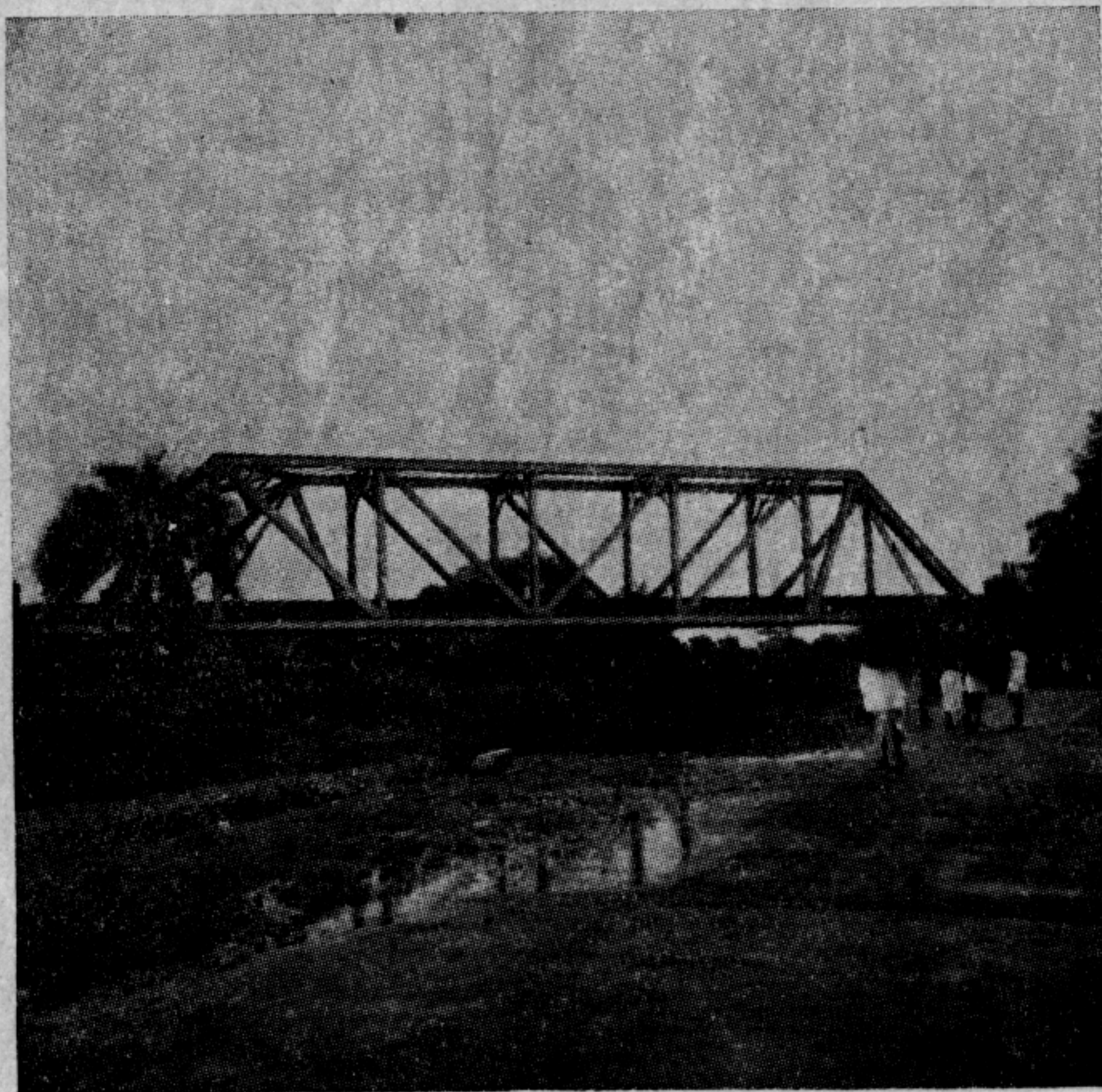


Plate 42.
Railway Bridge across Tolly's Nullah.

Photo—Sourananda Chatterjee.

Plate 43.
Suspension Bridge
within Ballygunge Lake
Area.

Photo—Siddhananda
Chatterjee.

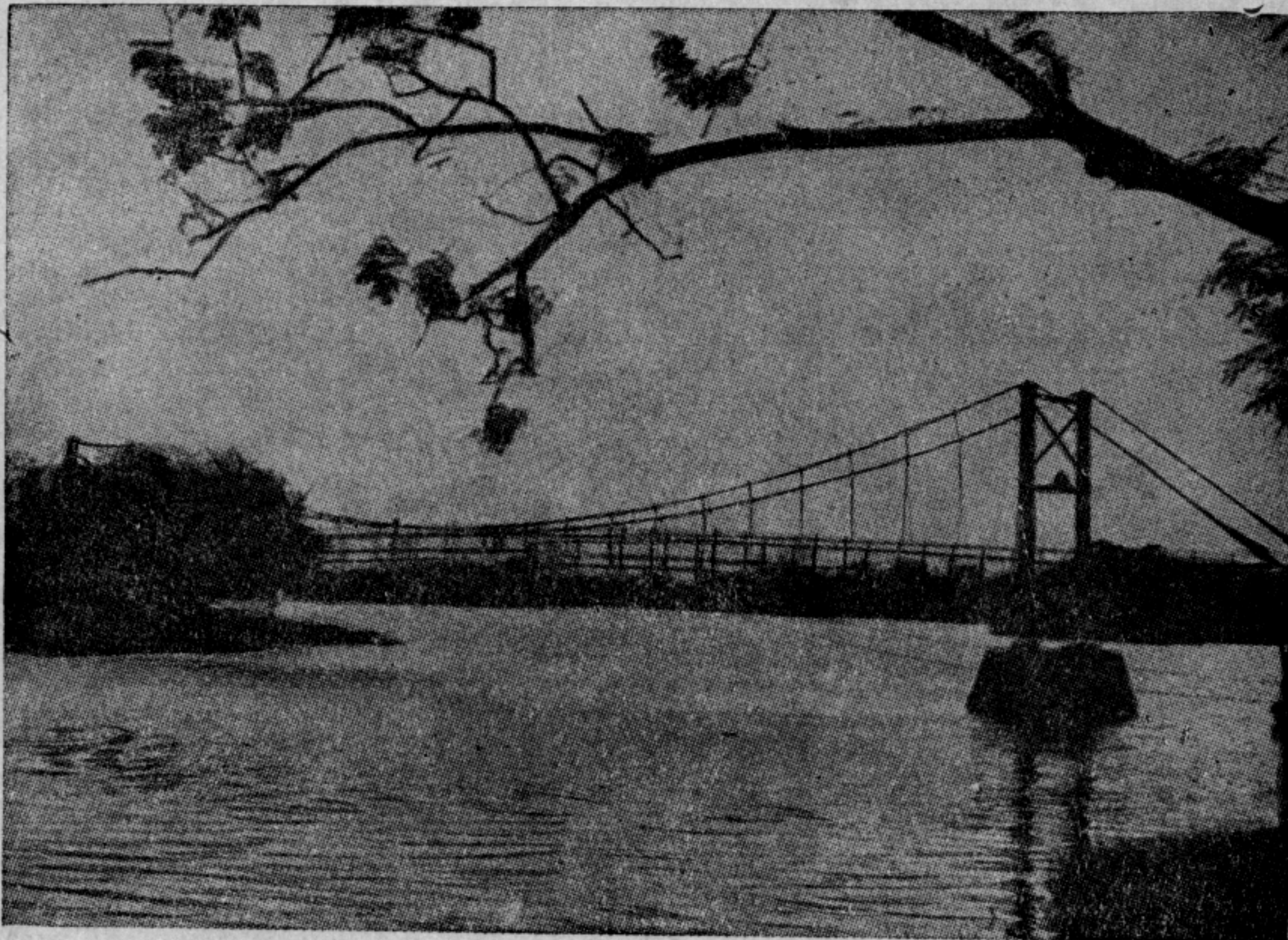
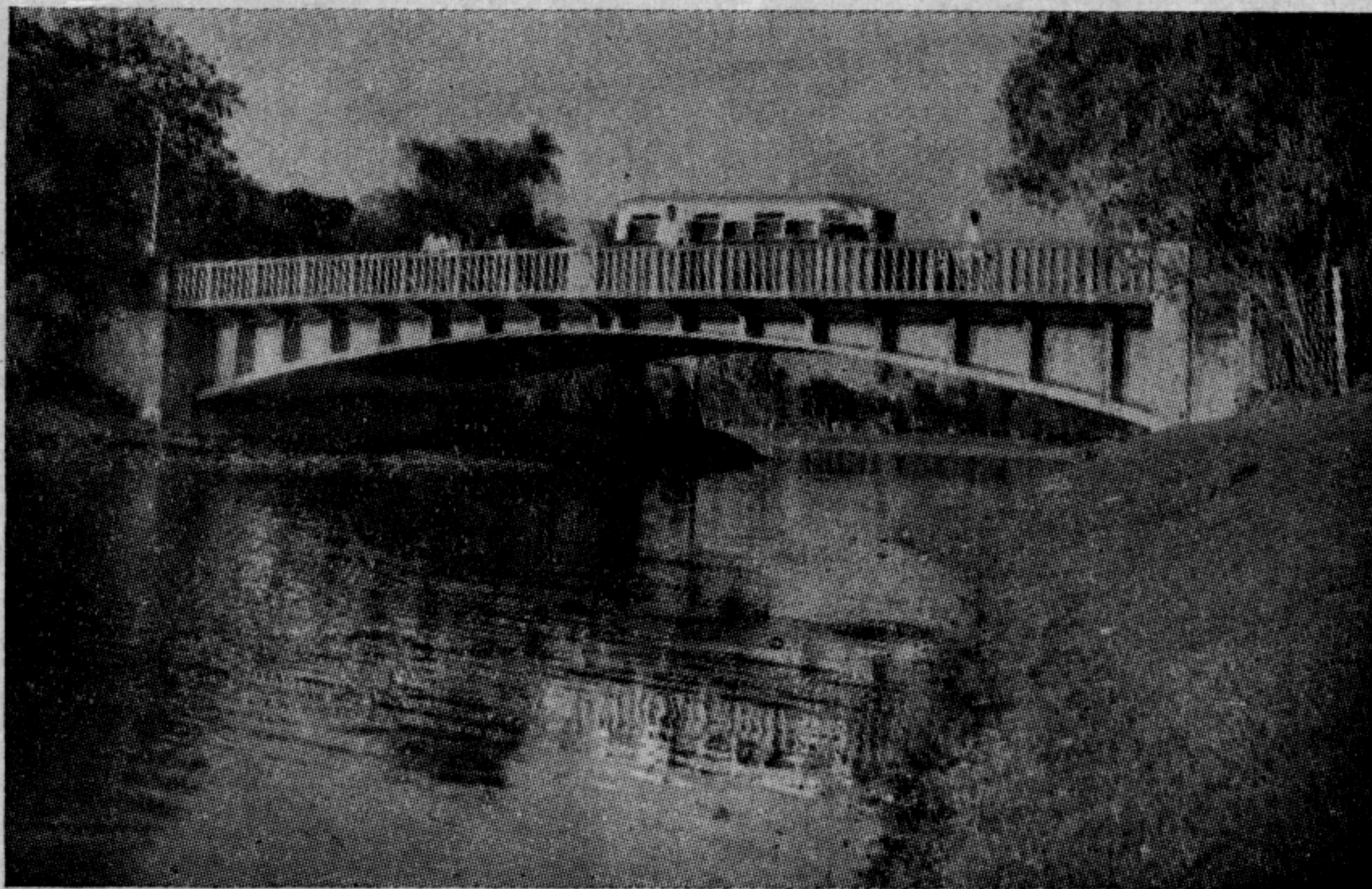


Plate 44.
R. C. Arch Bridge
within Lake area.

Photo—Author



both sides of the artificial lakes into one and to expose the bridge structure. Execution of the work was done by Messrs Associated Engineers Ltd. of Calcutta. Special attention was given in the design to keep the vertical clearance of the bridge above the high water mark of the lake so that the boat race regatta held by the rowing clubs are least affected even when two boats are racing side by side with speed.

CHAPTER VI

Bridges within Port area and across Boat Canal, Railway Bridges

Bridges of Calcutta Port Commissioners

In addition to the responsibility of maintenance of the new gigantic Howrah Bridge, the Commissioners for the Port of Calcutta are entrusted with the task of repair and maintenance of several bridges within Calcutta Port area. The Port Commissioners have constructed their docks, jetties, wharfs, railways and also canals connecting the river Hooghly and Tolly's Nullah. They have constructed not only non-movable orthodox types of bridges but also two typical swing bridges to maintain road links of Garden Reach and Circular Garden Reach Roads through the dock area. To receive sea-going vessels into the dock area, a canal has been cut leading into the dock. The water courses of the canal sever the links of Garden Reach and Circular Garden Reach Road. It is essential and imperative according to law to maintain continuity of the existing road links and the right-of-way of the users if such roads are not suitably and advantageously diverted for mutual benefit. The width of the canal near the bridge is considerably narrow and just sufficient to allow passage to cargo ships to enter into the dock area. To maintain this road link across the waterway, a bridge is necessary. When sea-going vessels enter into the dock, its masts and funnels reach a great height. In order to maintain necessary clearance above the maximum height of the ship's fixtures after computing the rise in level of the canal water due to flood tides during the rainy season, a permanent fixed bridge would have been a very difficult and costly project if the cost of abutments, approach roads, as well as the cost of land acquisition involved to accommodate the embankment for approach roads and many other engineering and economic factors were considered. As the canal is never in continuous use by the seagoing vessels, a movable or swing bridge is the economic solution to the problem when there is demand for the road to be in use almost without interruption.

The vertical lift-span bridge is an example of one of the movable span bridges. Two such bridges are in existence and operated by the Port Commissioners—one across Tolly's Nullah and the other across Circular Canal near Baghbazar. The old type of "swing-span" or "draw-span" bridge swings horizontally around a vertical axis which rests on the central pier or pivot pier at the middle of the channel. The central pier should be sufficiently wide so as to accommodate the whole width of the bridge structure at open position of the channel when rotated through one right angle and should be considerably longer than the standard pier so as to receive the whole length of the bridge over it. Instead of a single-span draw bridge there may be a double-span swing bridge structure. Calcutta has both the types of swing bridges. These types, however, are practically obsolete nowadays because there is the least scope of widening the roadway to accommodate increase in traffic volume. It involves higher cost of operation, maintenance and replacement of spare parts and the time of operation is twice or thrice as much as that of a single-leaf bascule or vertical lift bridge.

Another method of solution is bascule type bridge which swings upward on a horizontal axis. It may have either one-leaf or two-leaf movable structures. A typical

section of vertical swing or bascule bridge is given in Fig. 7. The above two primary types of bascule bridges may be divided into three general classes i.e.

- (i) Trunion type,
- (ii) Rolling Lift type, and
- (iii) Roller Bearing type.

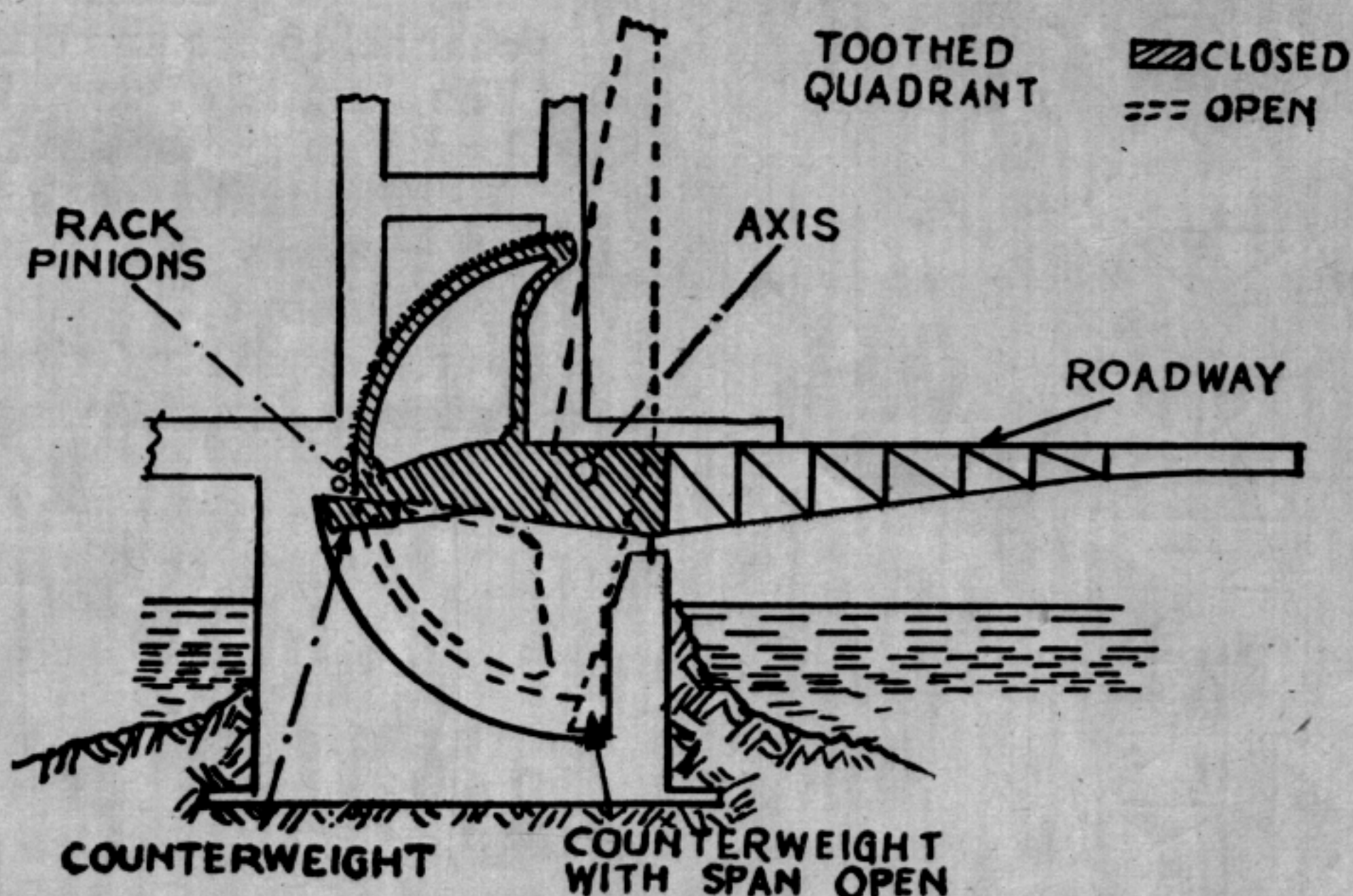
In the language of Dr. Waddell, "Each has its good points and each its bad ones ; and some are fitted for one location and not for another." Dr. Waddell early in 1920, in evolving a design for crossing the Hooghly river near Calcutta by a single span bridge, suggested a layout, the typical section of which is shown in the attached drawing, Fig. 8. incorporating a vertical lift portion at centre. The supporting of the counterweights which balance the weight of the movable span from the heights of the shore piers columns relieves both the cantilever as well as anchor arms from stresses due to counterweights.

27. Swing Bridge No. 1 on Garden Reach Road

It is an example of a single-leaf horizontally swing, steel-framed, through type bridge structure. Instead of swinging vertically and thereby lifting the projecting arm or arms up, this bridge of 221.5 ft span length swings horizontally in a clockwise and anti-clockwise direction to a 90° turn. It carries a clear roadway of 23.33 ft for both slow and fast moving traffic. The distance between two parallel booms is 26'-0" measuring from centre to centre of the structure. The steel structure was constructed in 1890 by Westwood Baille & Co. of London.

28. Swing Bridge No. 2

It is an example of horizon-



GEARING OF A BASCULE BRIDGE

Fig. 7.
Typical section of Bascule Bridge.

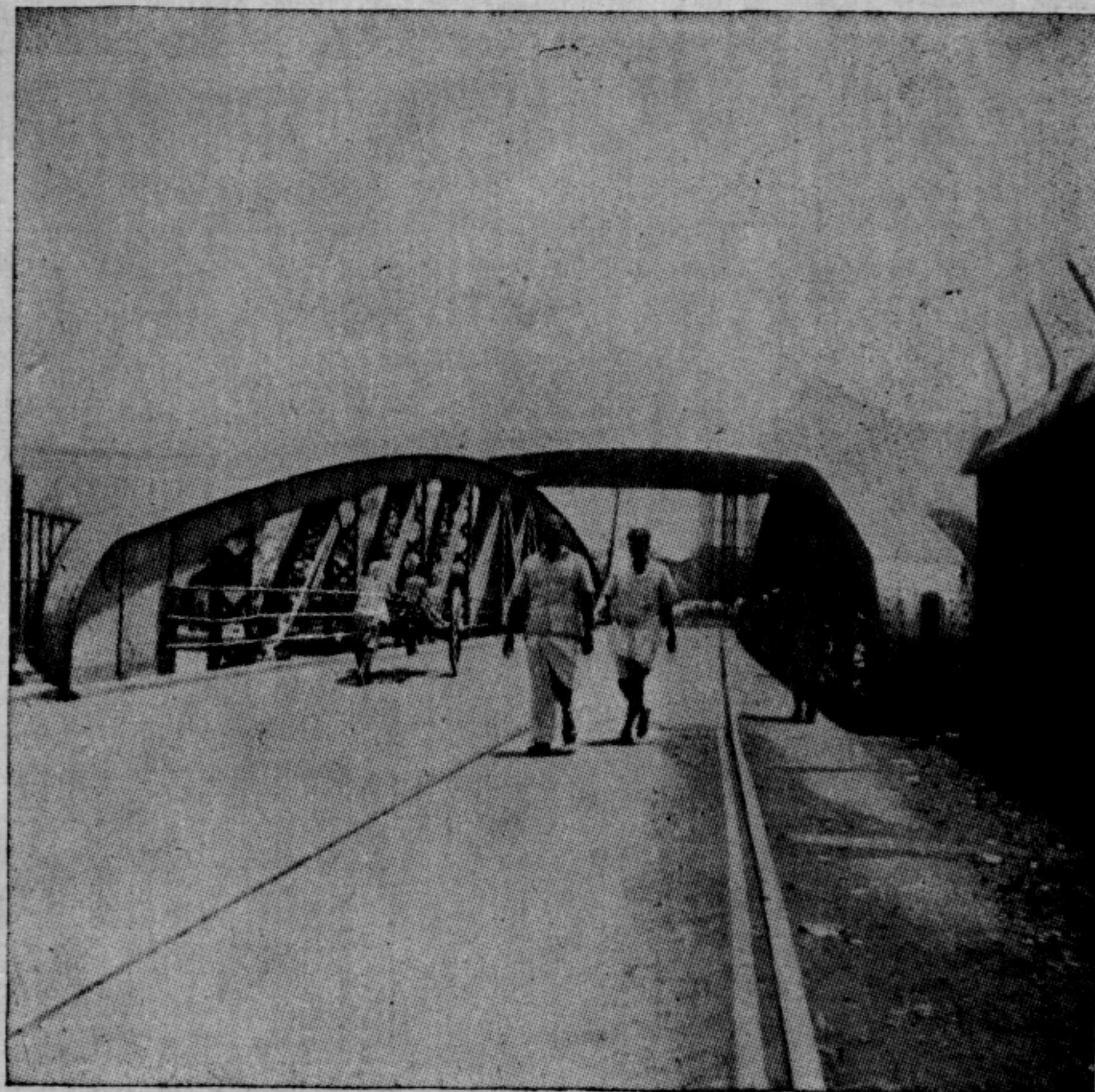


Plate 45.
Swing Bridge No. 1, Garden Reach Road, Kidderpore.
Photo—Author.

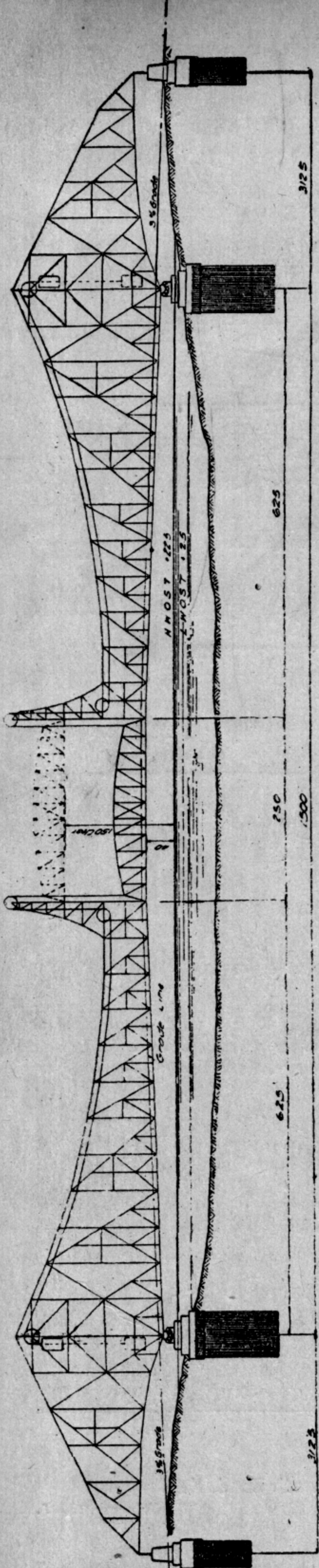


Fig. 8.
The proposed shape of the New Howrah Bridge according to Waddell (sometime in 1920).

tally swing double-leaf deck type bridge across the channel to accommodate Circular Garden Reach Road. The length of each leaf is 110'-6" to make the total length of the bridge 221 ft. There is no arrangement for segregation of fast and slow-moving traffic within the roadway of 21 ft but it has got an additional width to provide a footpath of 5.25 ft on either side of the bridge structure for pedestrian traffic. The road surface is of wooden scantlings.

29. Plate girder road bridge at Kidderpore Docks head along the Remount Road

It is an example of through-type plate girder situated at Kidderpore Docks head along the Remount Road. It has got only 21 ft span but the width of the roadway is 40'-6" which is tolerably good in relation to existing types of Port Commissioners' road bridges.

30. Majerhat Bridge

It is situated on the Diamond Harbour Road across the boat canal as well as over the Diamond Harbour Branch Line of Eastern Railway. It is an example of through-type latticed girder having a clear central span of 100 ft. On either side of the central span eleven brick arched spans supported on bent double headed rails covering a length of 95.25 ft on northern end and 115.5 ft on southern end were constructed. It accommodates also the tram tracks leading to Behala. The approach gradient on both sides of the bridge is one in fifty-six (1 : 56). It is a very narrow bridge having a 22.66 ft wide roadway only with two tram tracks laid on it. The matter of affording better communication facilities by replacing the existing bridge with a wider one was under consideration of the authorities. Now, the work has already commenced.

31. Durgapur Bridge

This steel framed latticed girder of 100 ft clear span on Alipore Road like Majerhat Bridge is also an example of through-type bridge at the middle portion. Two approaches consist of arched spans made of bricks and supported on double-headed, used bent rails on either side of central spans. The northern portion has a total length of 97.5 ft consisting of five spans. The approach gradient on the northern portion is one in seventy (1 : 70). The southern approach of 163.1 ft consists of nine spans. The southern approach has a gradient of one in sixty-three (1 : 63). The width of the roadway is exactly that of Majerhat Bridge i.e. 22.66 ft.

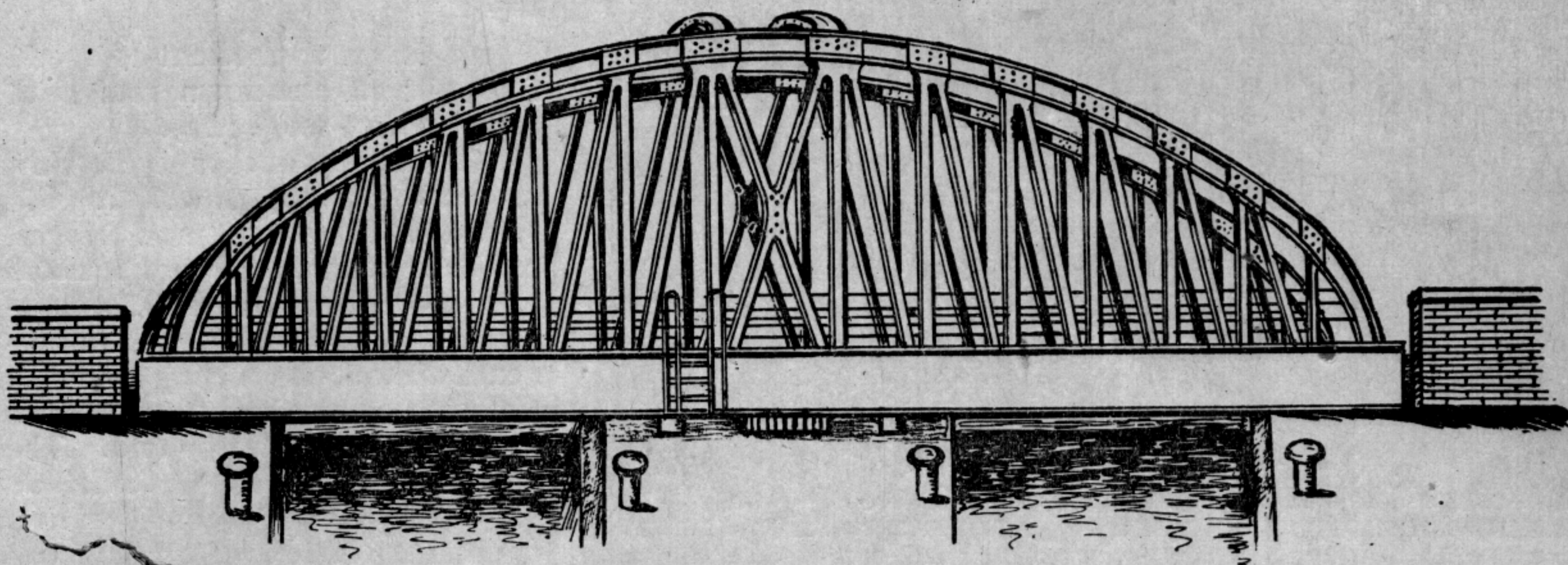


Fig. 9.

An Artist's sketch of Swing Bridge 2 on Garden Reach Road.

—T. Chandra.

32. Chetla Bridge

This mild steel latticed girder framed structure is also an example of a through-type bridge having a clear span of 70.25 ft and roadway of 20.83 ft only. The approach is sloped in an inclination of one in fifty-two (1:52) only. It connects Chetla Road across the canal. This steel structure was constructed by Messrs Burn & Co. in 1891 in their Howrah workshop.

kerbs is 71'-0" and the footpaths for pedestrians are 15 ft wide on both sides of the roadway beyond kerbs.

33. Jhingrapol Bridge

It is an illustration of a through-type bowstring girder steel bridge with a clear span of 155.75 ft. It provides roadwidth of 40 ft. The southern approach has a gradient of one in thirty-six (1:36) whereas the northern approach has one in forty-two (1:42). It is provided with a 6.5 ft wide footpath on either side of the girder.

The New Howrah Bridge comes within the jurisdiction of the Port Commissioners to which reference was made in Chapter I and III. The width of the roadway between

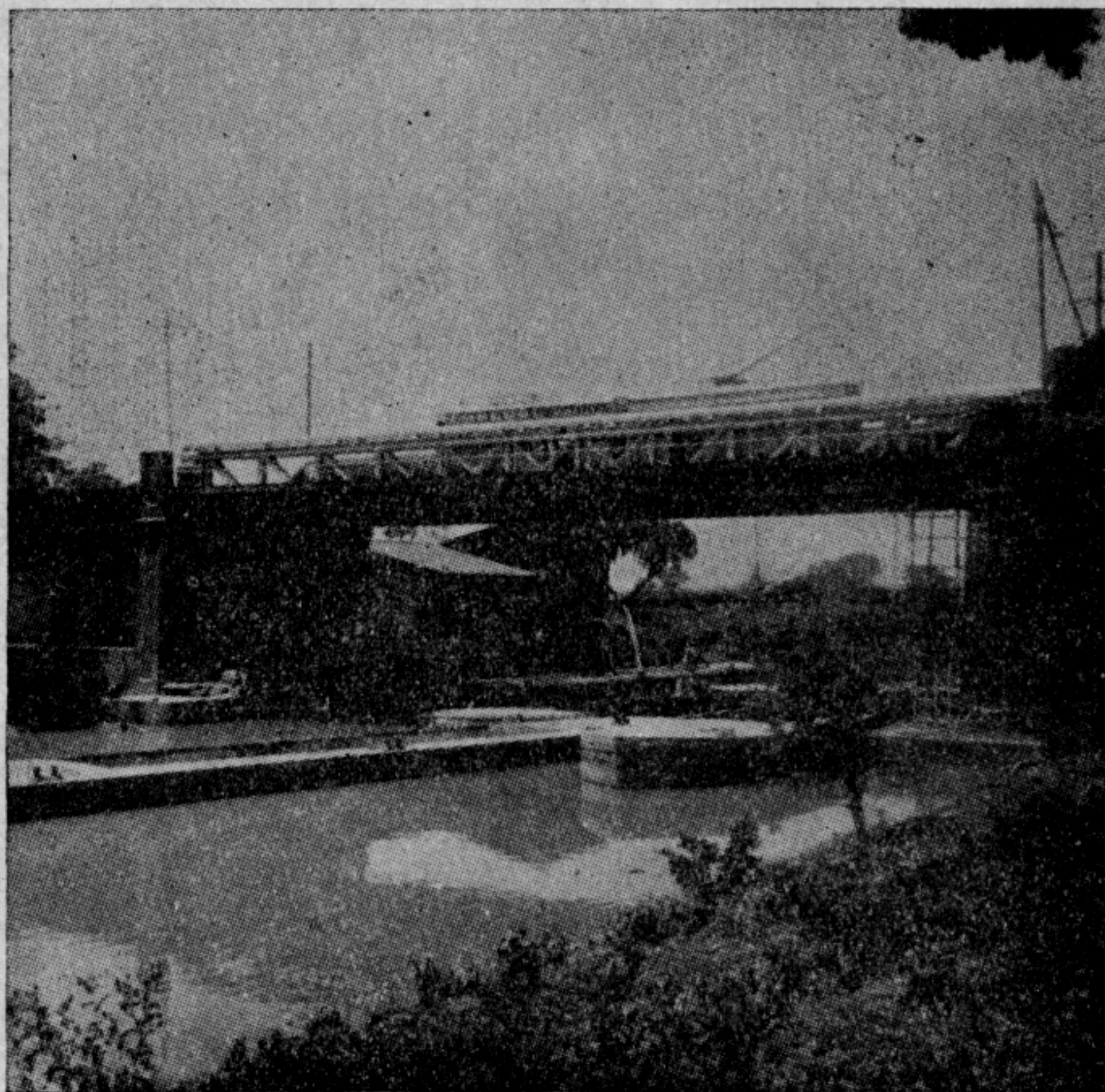


Plate 46.

Majerhat Bridge across Port Commissioners' boat canal with Behala tram passing over it.

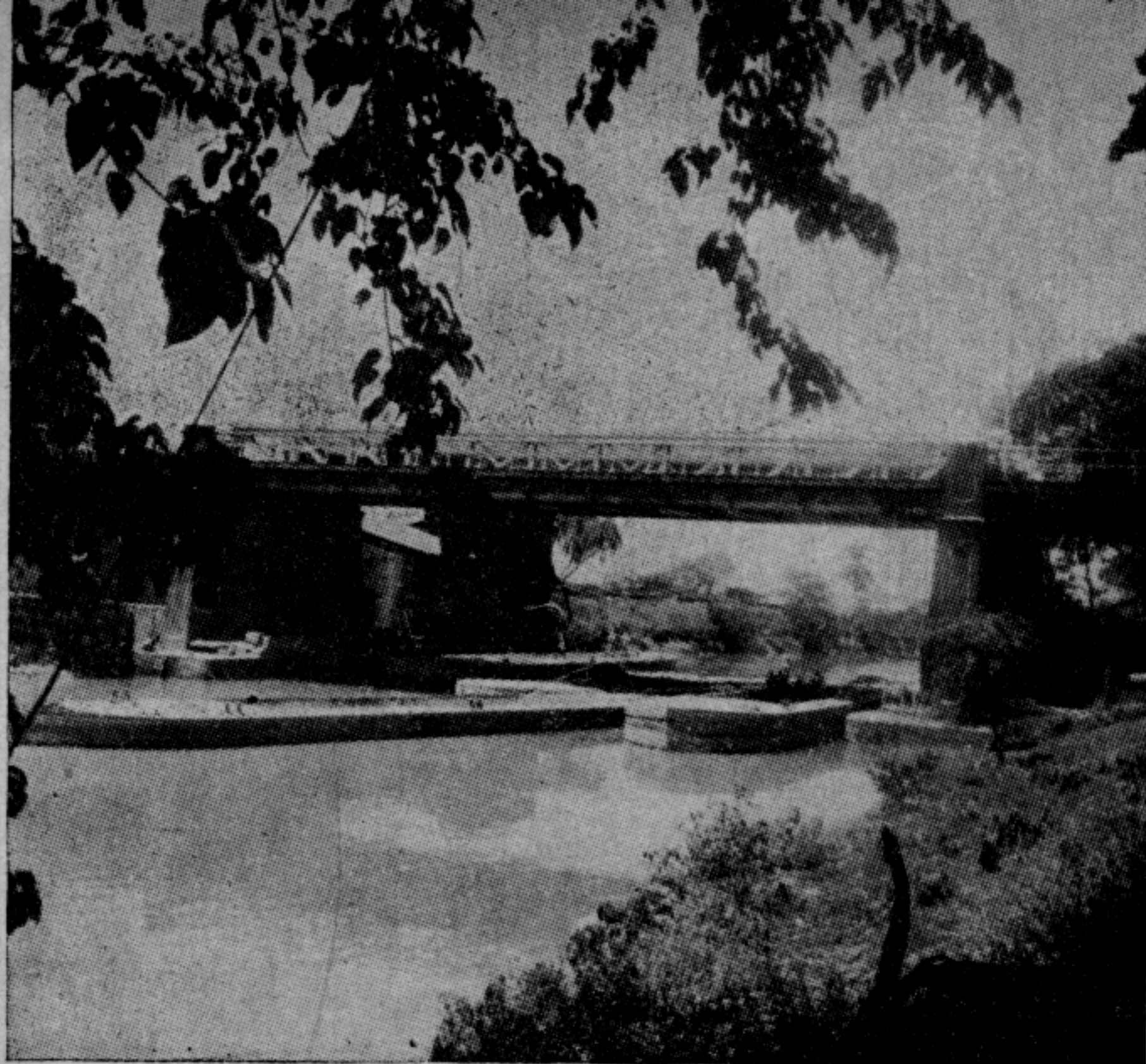


Plate 47.
Another view of Majerhat Bridge.

Photo—Author.

There is an upgradient of one in forty (1 : 40) and downgradient of one in thirty-six (1 : 36).

On the approaches to the New Howrah Bridge as well in Old Howrah Bridge very small bridges, rather culverts, were constructed to provide room for Port Commissioners' Railways to pass underneath without obstructing the traffic Calcutta on side and for proposed roadways on Howrah end. The utilisation of two existing R.C. Slab via ducts is under consideration for the diversion of traffic from Howrah end to Howrah Station without interfering with the flow of Calcutta-bound traffic. On approaches to the New Howrah Bridge spans ranging from 32 ft to 20 ft for Calcutta Port Commissioners' Railways on Calcutta side and also for vehicular traffic are provided.

In Outram Ghat a single span simply supported foot bridge of 16.5 ft span with 14.5 ft road-width and for Pani Ghat aqueduct eight simply supported foot bridges of 31 ft span covering a total length of 284 ft having road-width of 11.66 ft and an 8 feet wide footpath have been provided. On the north of Gwalior Monument a simply supported bridge of 11.1 ft width and having a single span of 37 ft arch and on the south of the Gwalior Monument an arched culvert of 29'-0" span with 4.5 ft footpaths are provided.

RAILWAY BRIDGES

In addition to the Railway terminal of Howrah, Calcutta has its own Railway station at Sealdah wherefrom emanate the suburban lines towards south : (i) Sealdah-Budge Budge, (ii) Sealdah-Canning, (iii) Sealdah-Lakshmikantapur, and (iv) Sealdah-Diamond-Harbour. Towards north there was a main

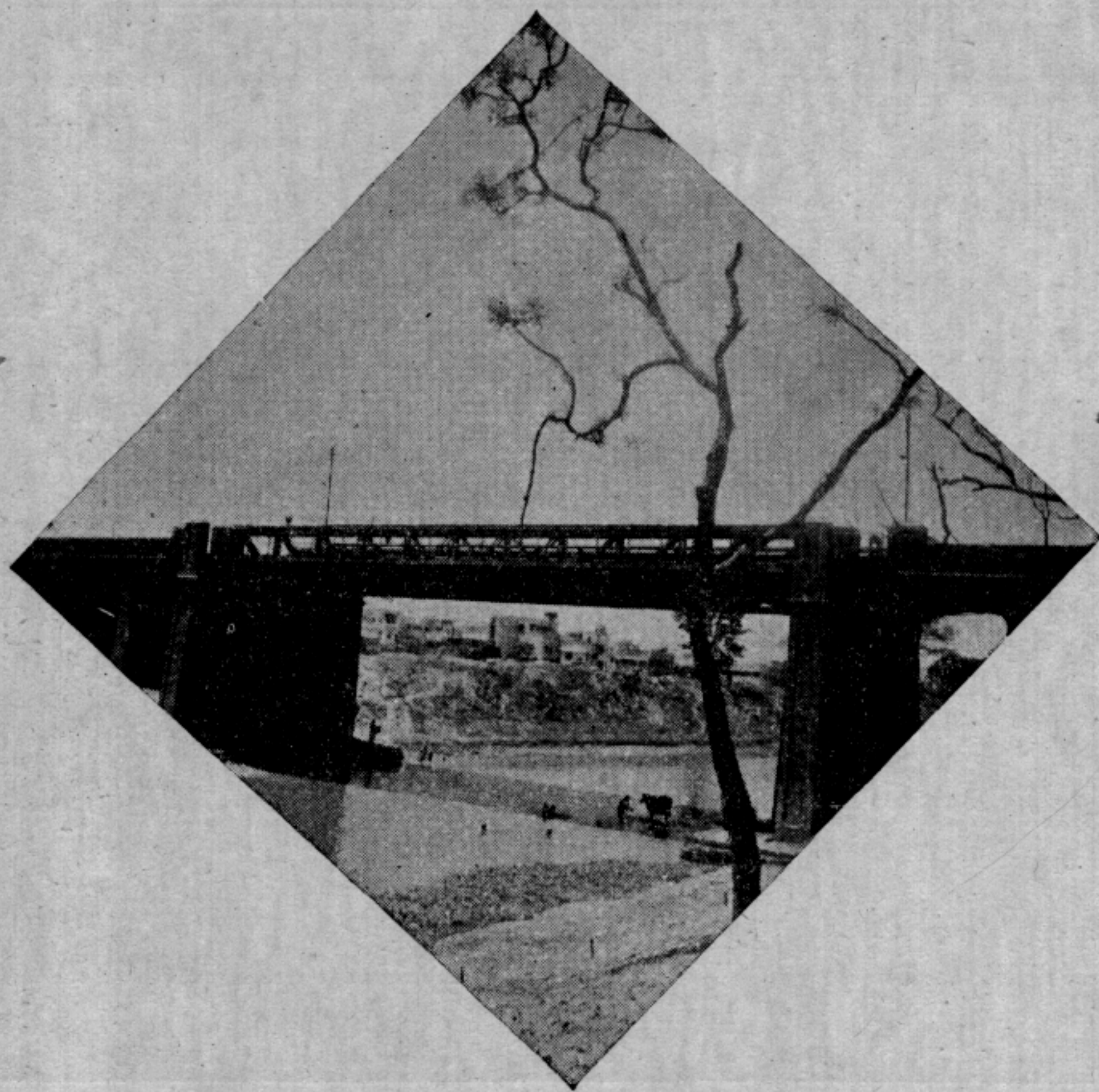


Plate 48.
Durgapur Bridge across Port Commissioners' boat canal.

Photo—Author.

broad gauge line before partition going up to Parbatipur for Assam and for Goalondo for Dacca and Siliguri to give link to Darjeeling. As a result of partition the main northern line of E. B. Railway, now Eastern Railway (Sealdah Section), extends up to Pakistan border i.e. Banpur Gede. There is a short branch line from Dum Dum junction to Baraset-Bongaon and another is the Calcutta Chord Railway which joins Sealdah Section with Eastern Railway's Howrah-Burdwan Chord Line at Dankuni across Vivekananda Bridge.

From Sealdah the railway line which is passing along the eastern border of the main city has to cross or pass over several roads going towards east from the old city. Near Sealdah Station Beliaghata Road, Ananda Palit Road, Dilkhusha Street and Convent Road have been taken over the railway tracks by over-bridge. Gobra Road, Gas Street, Sir Gurudas Road, Manicktola Main Road, Murari Pukur Road, Ultadanga Main Road, Jessore Road (under main line), Dum Dum Road, Russa Road and Tollygunge Road have been taken under the railway line providing a very restricted headway underneath. Gariahat Road has a level crossing where vehicular traffic is controlled by a pair of gates across the road on both sides of rail tracks. Russa Road is taken under a railway plate girder bridge. Sealdah-Budge Budge section passes along the Port Commissioners' boat canal. These bridges, as described under Port Commissioners' Bridges, have brick arched openings through which the railway track passes.

Along the northern portion of Sealdah Railway Station roadways are taken under railway bridges of different spans. The



Plate 49.
Another view of Durgapur Bridge.
Photo—T. Chandra.

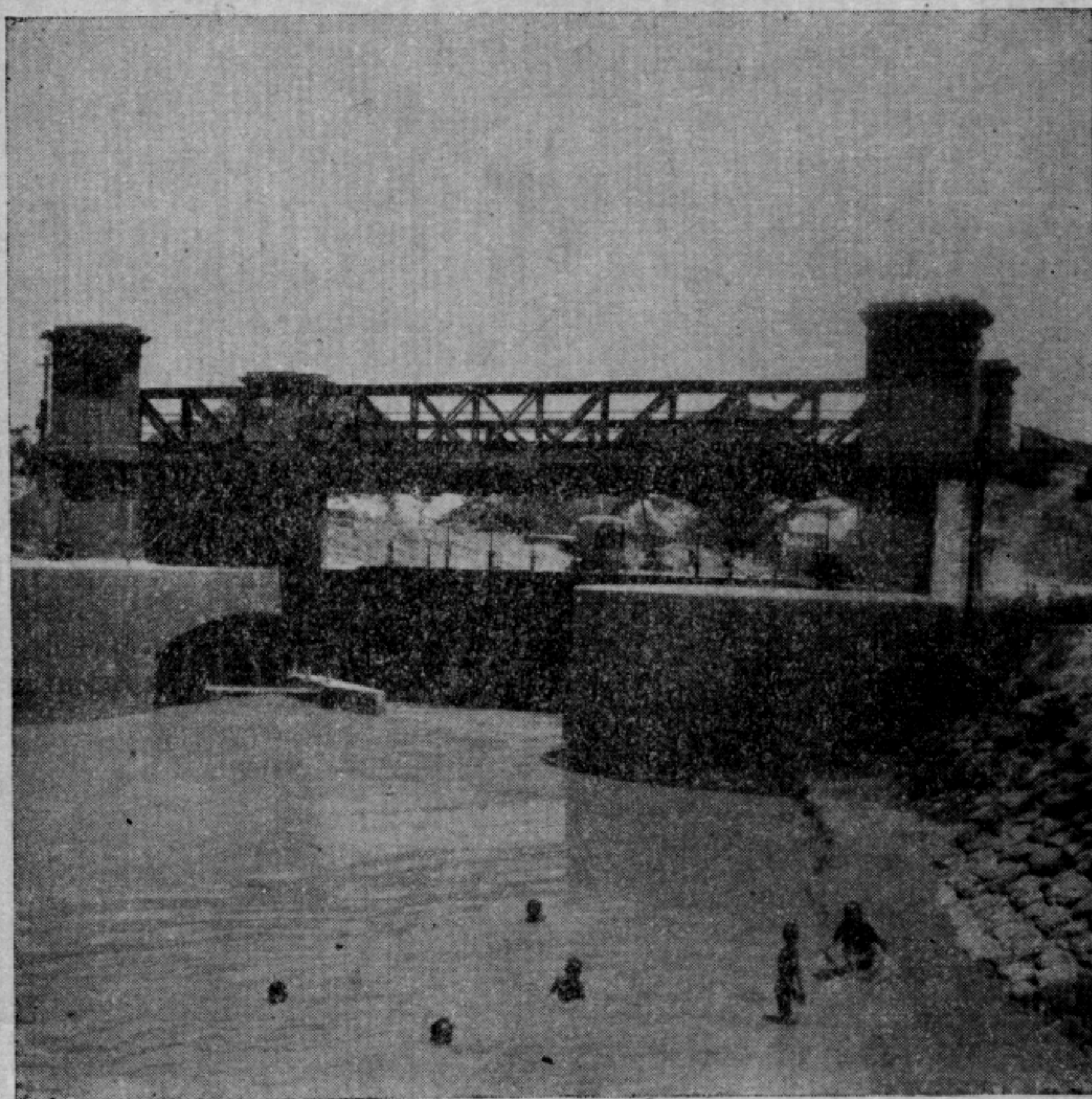


Plate 50.
Chetla Bridge across the Port Commissioners' boat canal.



Plate 51.
Jhingrapol Bridge side elevation.

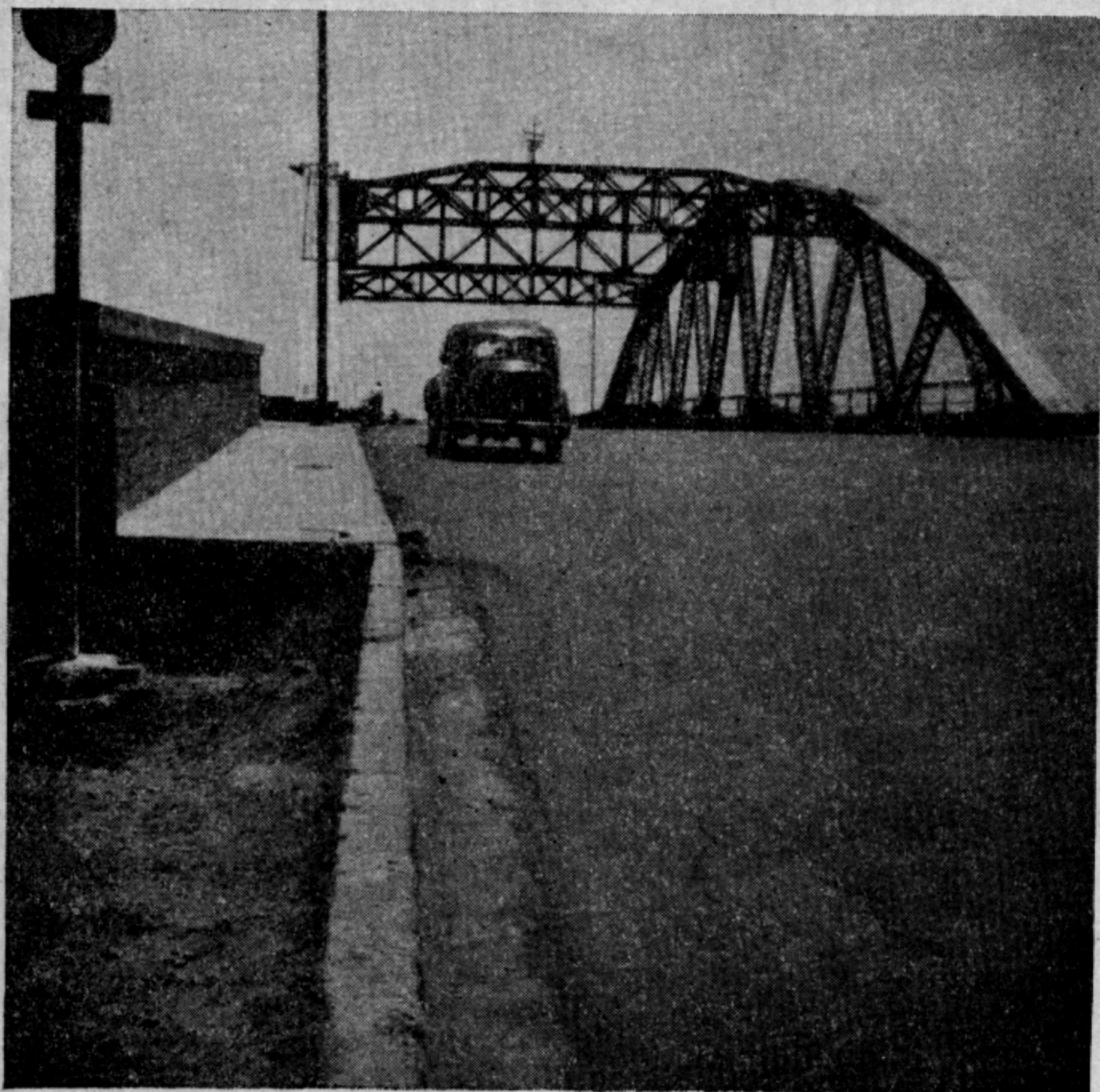


Plate 52.
A view of Jhingrapol Bridge from the road on it.
Photo—Author.

standard design and the stereotyped feature of railway bridges primarily are deck type plate girder which is a very economical section to span an opening where the wheel load of rolling stocks is transmitted through a pair of rail lines laid on the top boom of the girder at a specific distance of 5'-6". In some cases where sufficient headways for lorries and double deckers are necessary, through-type or half through-type plate girders are provided.

Sealdah Station is connected with railway lines to goods sheds of Chitpur Yard. In the link between Sealdah and Chitpur Yard railway tracks are taken over (i) Narkeldanga Main Road, (ii) Manicktola Main Road, (iii) Ultadanga Main Road and other minor roads. Rail lines are laid under Jessore Road, Barrackpore Trunk Road and Cossipore Road. The types of bridges as usual are either deck or through-type plate girders except in the case of Jessore Road which is taken above the railway line by an R.C.C. bridge constructed by the P.W.D. of the Government of West Bengal.

Photographs of typical plate girders near Kankurgachi and on B. T. Road near Baranagar Road Station of Calcutta Chord Railway popularly known as Dunlop Bridge are shown in plate 53 and 54 respectively.

Dunlop bridge

It is a late girder bridge across Barrackpore Trunk Road to carry two railway tracks. The abutment walls are at about 20° skew with the axis of rail. It has a clear span of 76'-0" measured across the road whereas the distance between abutments is 70'-0". The effective span of the bridge is

84'-0" whereas the overall length is 86'-0". The depth of the girder is 8'-0" and the clear headway is only 17'-6" from the top most camber of the B. T. Road.

Belgachia road bridge over railway line

The bridge on the Jessore Road at Belgachia is popularly known as Belgachia Bridge across the railway line. It is an admirable example of multi-span balanced cantilever R.C.C. Slab Bridge which consists of nine intermediate spans of 34.3 ft each and two approach spans of 24.3 ft each having a total length of nearly 358 feet. The width of the carriageway is 42 feet to accommodate four traffic lanes including a pair of tram tracks in addition to a nine feet wide footpath on either side with simple R.C.C. railings on outer edges.

The approach gradient is about one in thirty-three (1 : 33). The bridge was designed on the basis of single lane Indian Road Congress Class AA loading (70-ton Tank). The present bridge is a replacement of an old orthodox steel bridge of 22 ft wide carriageway having two narrow footpaths by its side. The bridge structure is at 25° skew with the axis of railway lines. The bridge rests on 15 inches thick R.C.C. piers on Franki-pile foundations. The depth of penetration of Franki-piles ranged between 60 and 65 ft below ground level. The total quantity of steel and cement used was 640 tons and 2,110 tons respectively whereas the total volume of concrete was 1.64 lakh cft. The substructures were constructed by B.B.J. and Co. Ltd., whereas the superstructure was done in two longitudinal halves by Messrs Gannon Dunkerley and Co. Ltd. and



Plate 53.
Kankurgachi Railway Bridge.
Photo—T. Chandra.

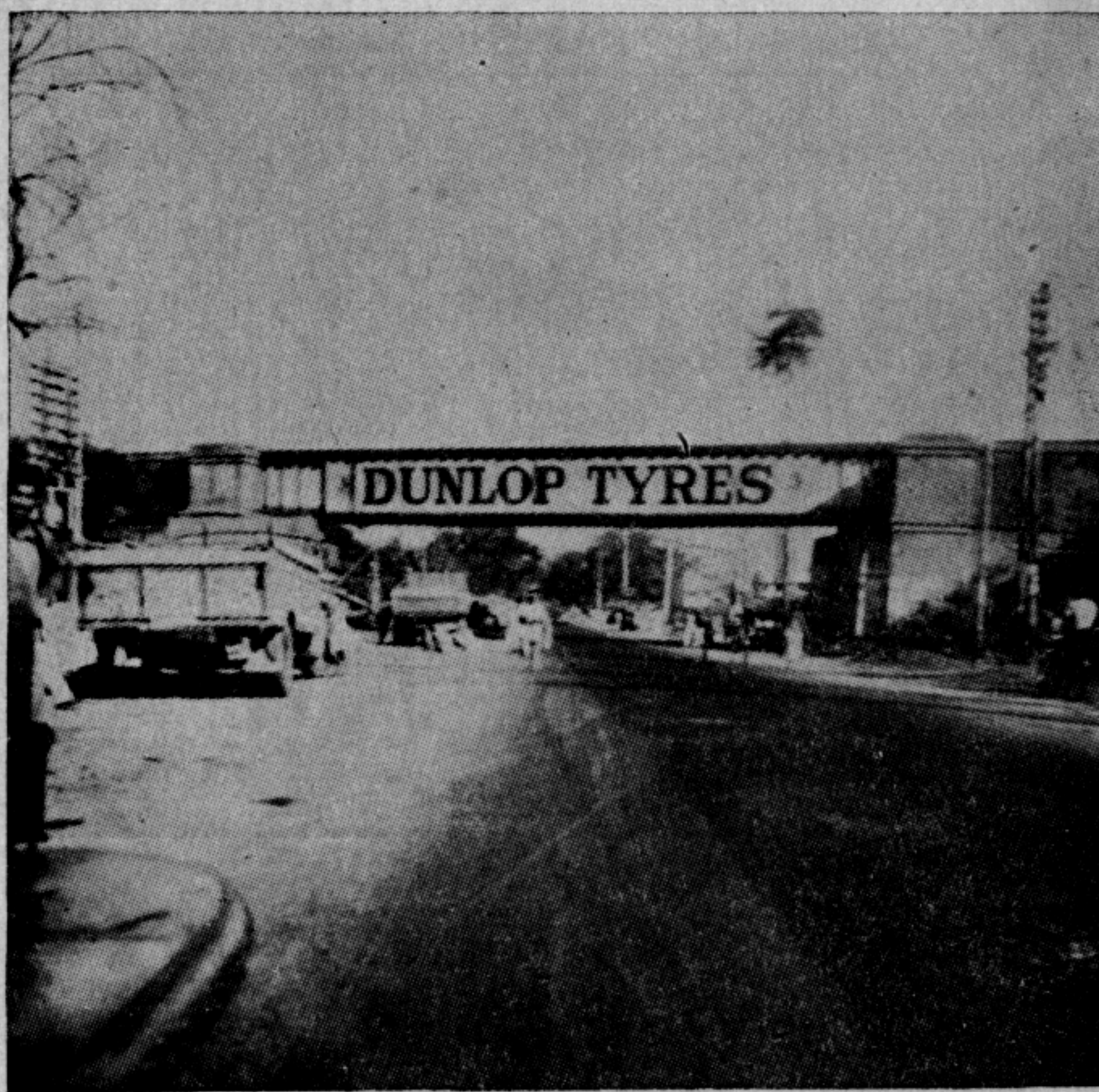


Plate 54.
Calcutta Chord Railway Bridge over Barrackpore Trunk Road
near Baranagar Road Station.
Photo—Author.



Another view—Calcutta Chord Railway Bridge over Barrackpore Trunk Road near Baranagar Road Station.

Photo—Author.

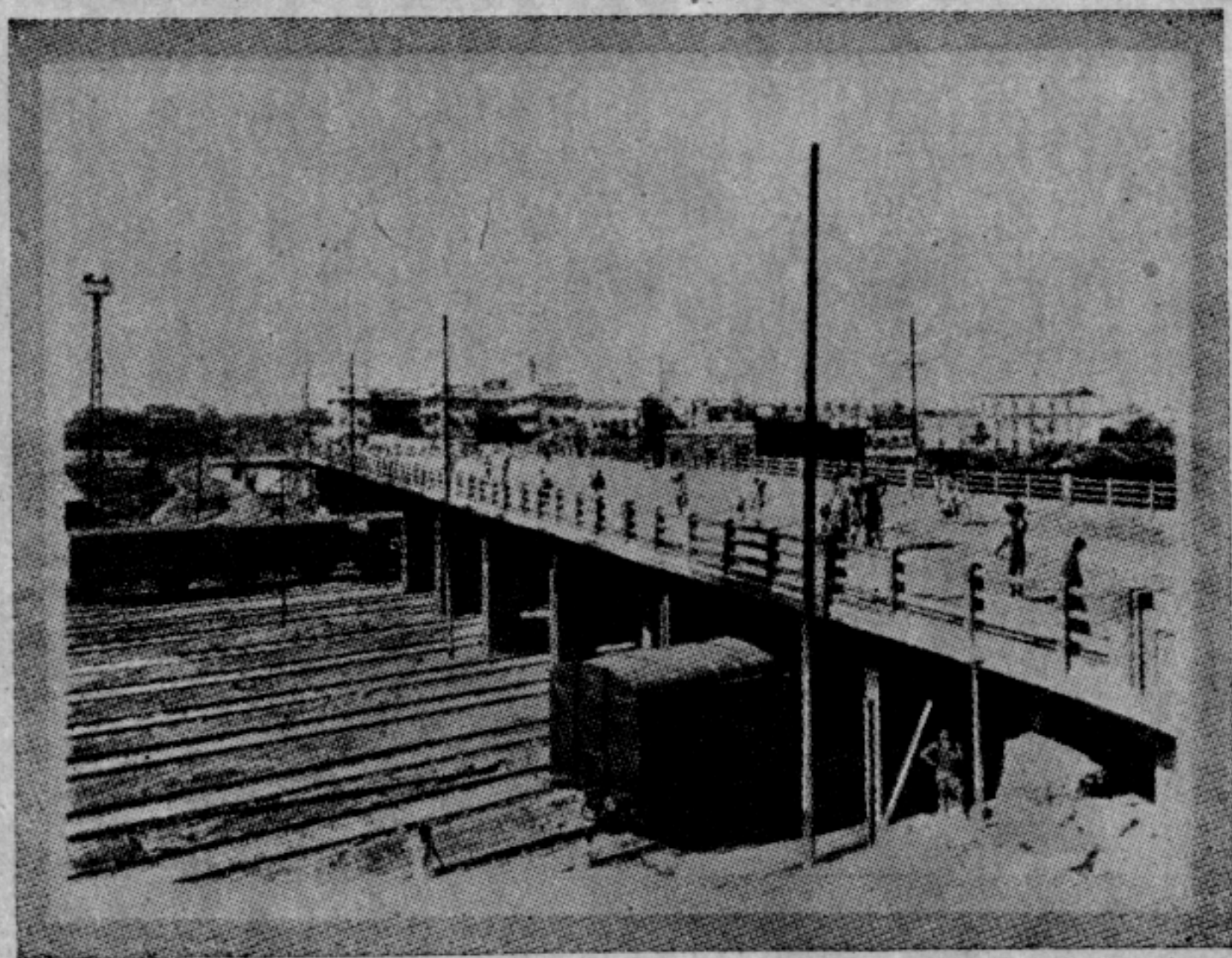


Plate 55.
Belgachia Bridge.

Messrs Nanji Mavji and Co. respectively. The bridge was opened to traffic on the 6th January, 1954.

Gariahat Road Bridge

With the expansion of the city of Calcutta towards south i.e. Gariahat, Jadavpur, Dhakuria and establishment of Jadavpur University, its Polytechnic, National Instrument Factory, Glass Research Institute, etc. in those areas, the importance of the Gariahat Road has increased immensely. But consequent to the closure of the railway level crossing gates on the Gariahat Road, traffic flow comes to a standstill for a certain period. It causes not only inconvenience but also loss of many man-hours

due to useless waiting in queue in cars and buses. To obviate these difficulties it has been considered necessary to replace the level crossing by a bridge. With that object in view the Calcutta Improvement Trust is busy in constructing an approach road for the proposed bridge. The construction of the bridge proper will be subsequently undertaken by the Eastern Railway across the railway property.

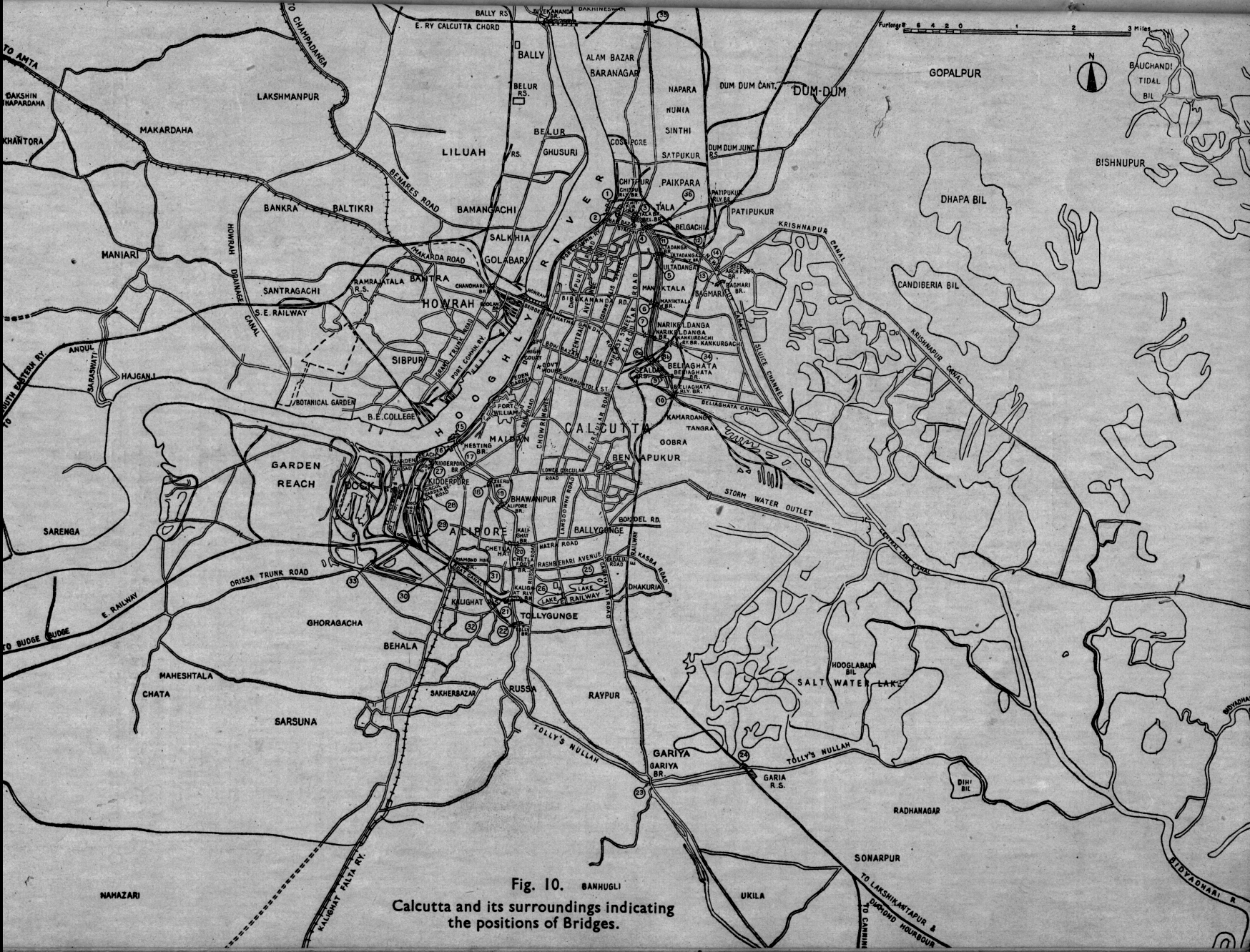


Fig. 10. **Calcutta and its surroundings indicating the positions of Bridges.**

CHAPTER VII

Bridges within Greater Howrah

Though there is practically no canal within the city limits of Howrah, it has its own drainage canal land acquired nearly half a century ago passing almost along the periphery of a portion of the municipality on the west with the object of constructing a main drain for the efficient drainage of the city. To form a Greater Howrah region, the western boundary has been taken as the Howrah Drainage Canal of the Irrigation and Waterways Department of the Government of West Bengal, which was constructed sometime in the later half of nineteenth century in place of the almost dried up course of the old "Mahishdhara" Canal. Mahishdhara Canal was originally constructed for a short length by the then landlords of the locality for irrigation, navigation as well as drainage purposes. The city is criss-crossed with railway lines and is occupied considerably by railway properties in the form of tracks and structures for offices, quarters, godowns, stations, etc. It covers a sizeable portion of the total area of the city usurping nearly one eighth portion of the municipal Howrah. To maintain through communication, sometimes the roadways are taken above the rail lines and sometimes under the railway tracks. There is no river worth the name other than the Bhagirathi which forms the eastern and southern boundary of the district and of Greater Howrah. Bally Khal forms the northern boundary of a portion of Howrah district as well as Greater Howrah. The Saraswati and the Damodar pass through the district to meet with the Bhagirathi whereas a part of the Rupnarayan river separates this district from Midnapore. Several narrow and small masonry bridges across the Howrah Drainage Canal have been constructed to accommodate roadways.

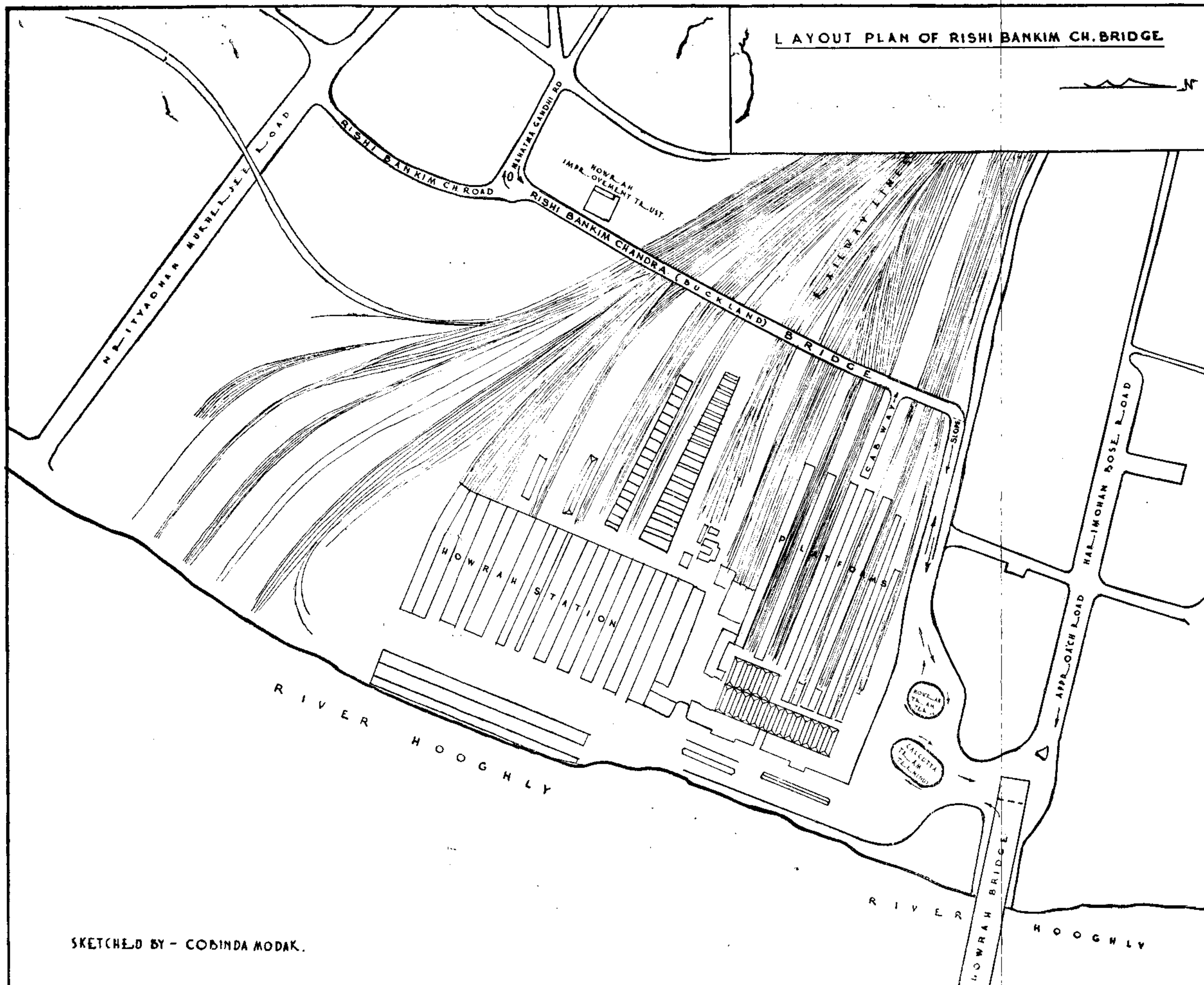
Within the city proper there are several road and railway bridges. During the laying of railway lines the old existing roads in some places have been carried by overbridges constructed by the Railways and in some cases railway lines were conveniently taken by constructing railway bridges. As in the case of Calcutta, we have considered bridges across the canal at the very outset but in the case of Howrah, railway lines form the major obstruction to road communication.

From Howrah Station situated just on the western bank of the river, the Eastern Railway goes slightly towards the west and takes a northerly swing whereas the S. E. Railway moves westward through a short s-curve. If the enumeration of bridges commences from Howrah Station proper, first in the series comes Buckland Bridge (now Rishi Bankim Bridge to commemorate the name of the greatest Bengali novelist and the father of "Vande Mataram"). Then comes Chandmari Bridge to carry Grand Trunk Road, Tekiapara Footbridge, Bamangachi Bridge to carry Banaras Road. There are few other plate girder bridges over the minor roads to carry the permanent ways of the Eastern Railway.

From the take-off of South Eastern Railway line all bridges are Railway Deck type plate girder or suitably strengthened heavy rolled steel joist bridges as over

- (i) The main drain near the north-west corner of Bally Park.
- (ii) Madhusudan Pal Chowdhury Lane,
- (iii) Natabar Pal Road,
- (iv) Makardah Road, and other minor roads.

Other roads pass over level crossings till the Howrah Drainage Canal is crossed. Railway



LAYOUT PLAN OF RISHI BANKIM CH. BRIDGE

SKETCHED BY - COBINDA MODAK.

Plate 56.
Buckland Bridge approach road. On the right Abul Kalam Azad Road (road connecting the Grand Trunk Road and Howrah Bridge).

Photo—Pratap Das



bridges across the Saraswati, Rajapur Drainage Canal, Damodar river and finally the Rupnarayan were constructed by S. E. Railway up to the Howrah district boundary. Across Bally Khal there are two sets of bridges—one for the Grand Trunk Road (old and new) and the other for the Eastern Railway. The recently completed Damodar Road Bridge is an example of a simply supported prestressed (Magnel system) reinforced concrete structure. Preliminary work for the Rupnarayan road bridge is under way.

A. Road bridges across railway line

(1) *Buckland Bridge (Rishi Bankim Chandra Bridge)*: It is a very long steel structure bridge. Here rolled steel joists and cross beams are fixed with the vertical steel stanchions placed very close to one another. A portion of the bridge has half-through plate girders with clear spans just over 70'-0". The construction of the bridge was considered necessary for providing passage to pedestrians and for vehicular traffic and subsequently to accommodate tram tracks. The old road was obstructed by the series of railway lines within the Howrah Railway Station Yard. In the map of Howrah of 1793, roads and foot tracks are shown within paddy fields and gardens where very few structures existed. But the present bridge was constructed by the East Indian Railway to provide facilities to maintain the right of the way of the public. The total length of the bridge, including the approach from the existing ground level, is just over 1926 feet. It has got several lengths of spans and carriageways of varying widths. Clear span ranges between 71'-4" on the higher side to as low as 10' nearly for reasons best known to the then engineers. The width of the road ranges from 33'-6" to 35'-0". There is a clear headway of 16'-1" above the railtop. It is situated nearly 500 yards from the river running almost parallel to it. It carries two tram lines on the western side and roads for fast-moving vehicular

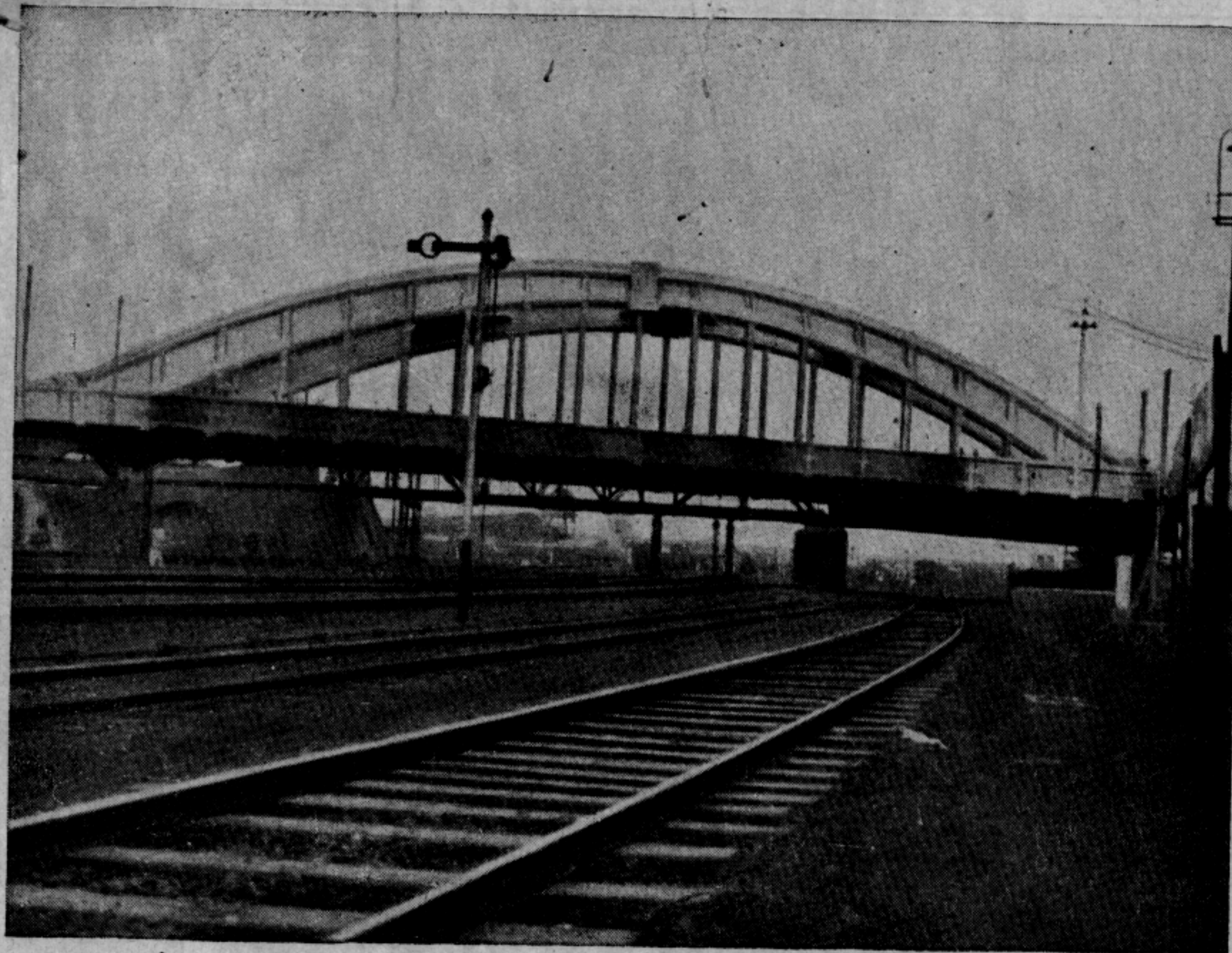


Plate 57.
Chandmari Bridge on
G. T. Road.
Photo—Author (1936)

traffic on the east whereas there are two footpaths of the minimum width of 6 ft on both sides of the bridge. These footpaths, a few inches above the level of the road, were constructed of wooden sleeper-sawn planks which have been lately replaced by R.C. slabs. Slow-moving vehicles and loaded lorries are not permitted to pass over the bridge to avoid traffic congestion and to ensure safety of the bridge. Footpaths have railings on the outer side closed by galvanised corrugated iron sheets six feet high to obstruct the view of the Howrah Station Yard. A network of railway lines passes underneath it. It has an approach gradient of one in twentyfour (1:24). It seems the slope is steeper than the normal gradient. Empty lorries are now permitted to ply over the bridge.

(2) *Chandmari Bridge*: It is an example of skew reinforced concrete bowstring girder bridge on Grand Trunk Road over the

Eastern Railway line to carry both fast and slow-moving traffic. It has a clear span of 215'-6" and an effective span of 221'-6" and provide a clear headway of 18'-0". It carries 8'-4" wide footpaths on both



Plate 58.
Tekiapara Footbridge across Eastern Rly's track.
Photo—T. Chandra

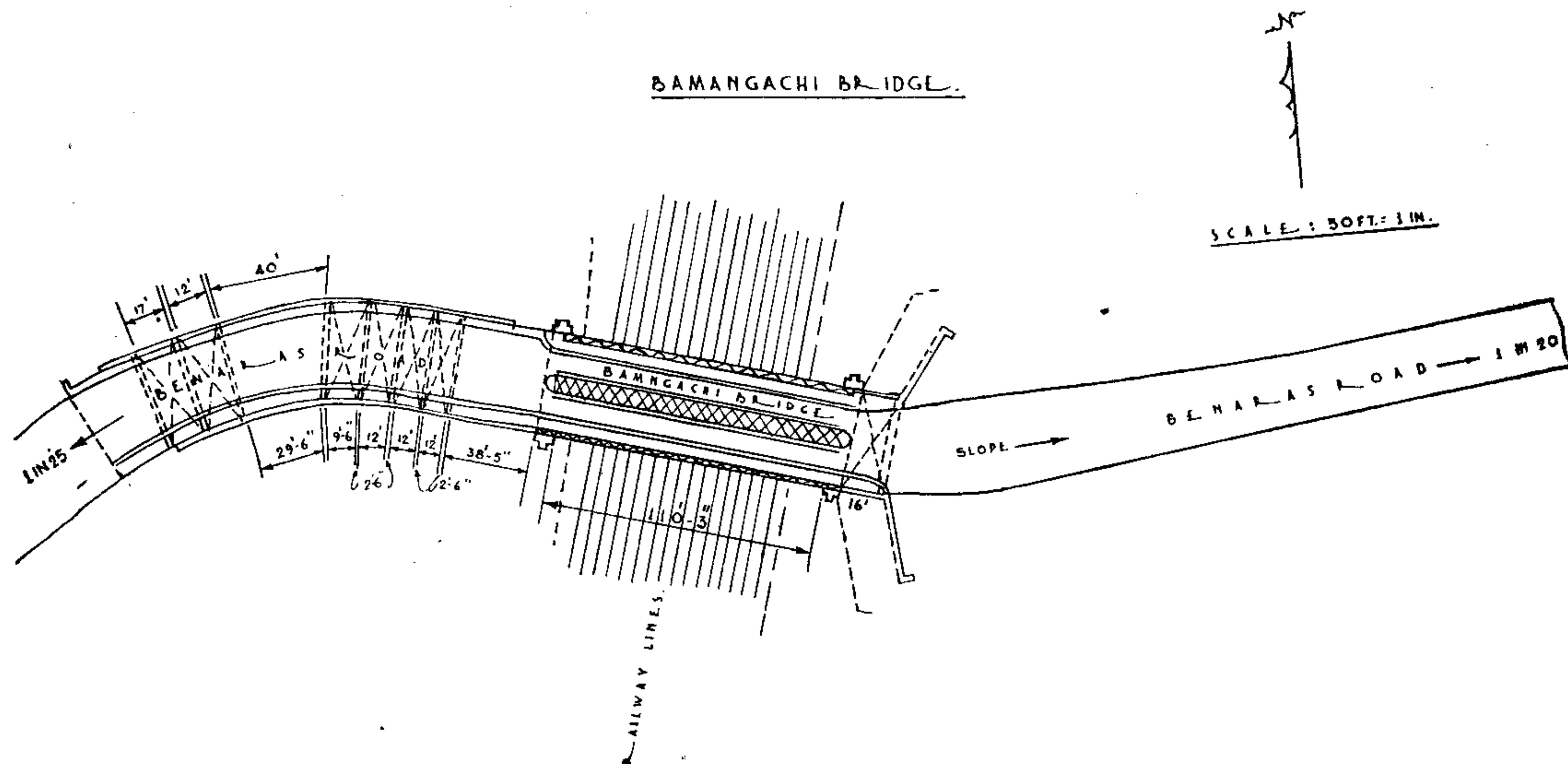


Fig. 12.
Bamangachi Bridge

sides of the bridge structure proper outside the bows. The approach road has a gradient of one in forty (1 : 40) but it has practically no footpaths on the northern approach but only partly on the southern side. It has a road-width of two inches less than 35 feet. Because of the mixed nature of the traffic it is a very congested bridge on the G. T. Road. It carries mostly slow-moving traffic which is not permitted to avail of the Buckland Bridge in addition to the fast-moving and bus traffic. One of the reasons for the great congestion on the bridge is a bus stop for Government buses of Routes No. 36B and 24 on the bridge top.

(3) *Tekiapara Footbridge*: As it is a footbridge the approach of the bridge was not made on an inclined plane but connected with a staircase composed of a series of steps till the bridge height is attained. The bridge consists of a latticed steel structure and cross beams over which wooden planks are fixed to accommodate the footpath. It has a total length of 493'-4" and is provided with a 8'-6" wide footpath.

(4) *Bamangachi Bridge*: It is an example of plate girder and masonry arch bridge to accommodate Banaras Road for all kinds of traffic. It has two separate bridge structures, one for up and the other for down traffic. From the abutment wall there is a masonry arch of 16'-0" clear span which is followed by four sets of plate girders of 110'-3" clear span, four sets of plate girders of 38'-5" clear span and three masonry arches of 12 ft each and then an arch of 9'-6", four sets of plate girders with average clear span of 36'-0" (range from 29'-8" to 40'-0" as the bridge is on skew) and two masonry arches to complete the bridge proper. The road has a slope of one in twentyfive (1 : 25) on the western and one in twenty (1 : 20) on the eastern approach. The average width of the road is 26 feet. It has a clear headway of 18 ft from the top of the railhead to the underside of the deepest girder.

B. Railway bridges over existing roads

(5) *Madhusudan Pal Chowdhury Road Bridge*: It is an example of built-up girder of 22 inches depth to span the gap of 19'-10". The plate girders are placed on abutment walls at a spacing of 5'-9" centre to centre separated by a gap of 8'-3" in between tracks. The length of the abutment wall is sufficient to carry more railway tracks. The effective span is 21'-6" and overall length of the girder is 23'-3". There is a clear headway of 10'-0" only. So, a heavily and highly loaded lorry cannot pass under it.

(6) *Natabar Pal Road Bridge*: It consists of four plate girders placed in pair separated by a spacing of 5'-7" centre to centre. The gap between the centre line of

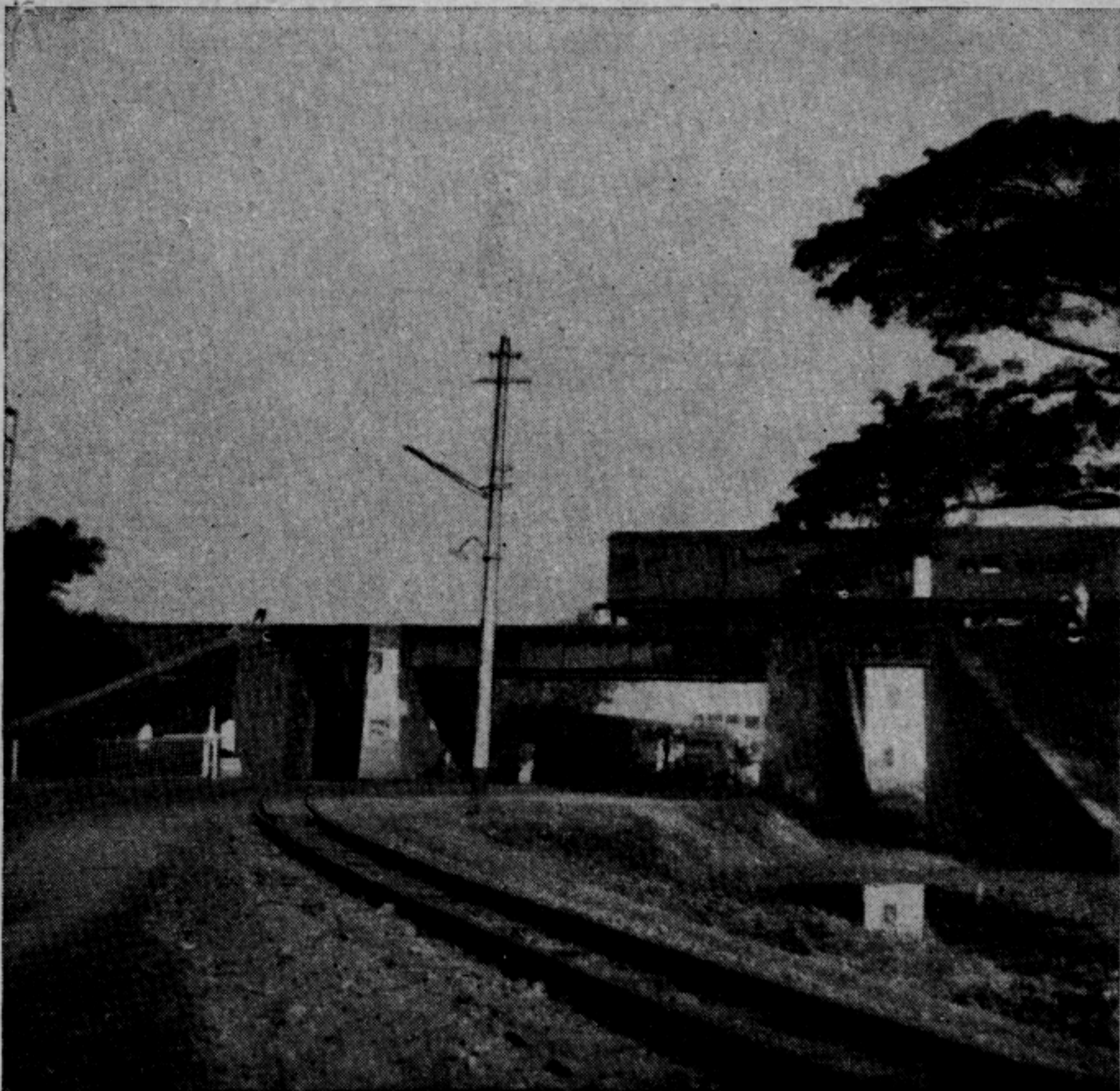


Plate 59.

Makardah Road (near Dasnagar Rly. Stn.) Bridge.

Photo—Author.



Plate 60.
Masonry arch across Howrah Drianage Canal.

the pair of girders is 15'-5" (9'-10" + 5'-7"). The clear span is 39'-4" whereas the effective span is 41'-8" and the overall length is 44'-0". The depth of the girder is 3'-7½". The clear headway is 12'-4". The length of the abutment wall is 46'-2" and its top width is 2'-10". Railway line is laid on the level permanent way.

(7) *Bridge across a private road in Sanpur Jala area:* The built-up girder of 24½" deep (I-section beam strengthened at the top and bottom with mild steel plates) bridges a clear gap of 20'-0". The effective span and overall length of the girders are 21'-8½" and 23'-3" respectively. The length of the abutment wall is 46'-0". It carries two tracks for the present with future provision to accommodate more tracks. There is a clear headway of 13'-0" only.

(8) *Makardah Road (near Dasnagar Railway Station) Bridge:* It is also a plate girder bridge to span a length of 40'-4" at the centre and two side spans of 10'-5" and 10'-8" respectively to carry broad gauge railway lines of the South Eastern Railway. The overall depth of the plate girder is 3'-7" having flange width of 1'-8½". The side spans are bridged with 24" × 7¾" R.S.J. Under the central span, Makardah Road and Martin's Light Railway lines for Amta and Seakhala pass. Underneath the side spans, two main drains meander. The total length of the plate girder is 44'-1". The clear headway is 12'-2" from Martin's Light Railway lines and 12'-8" from the crest of the road.

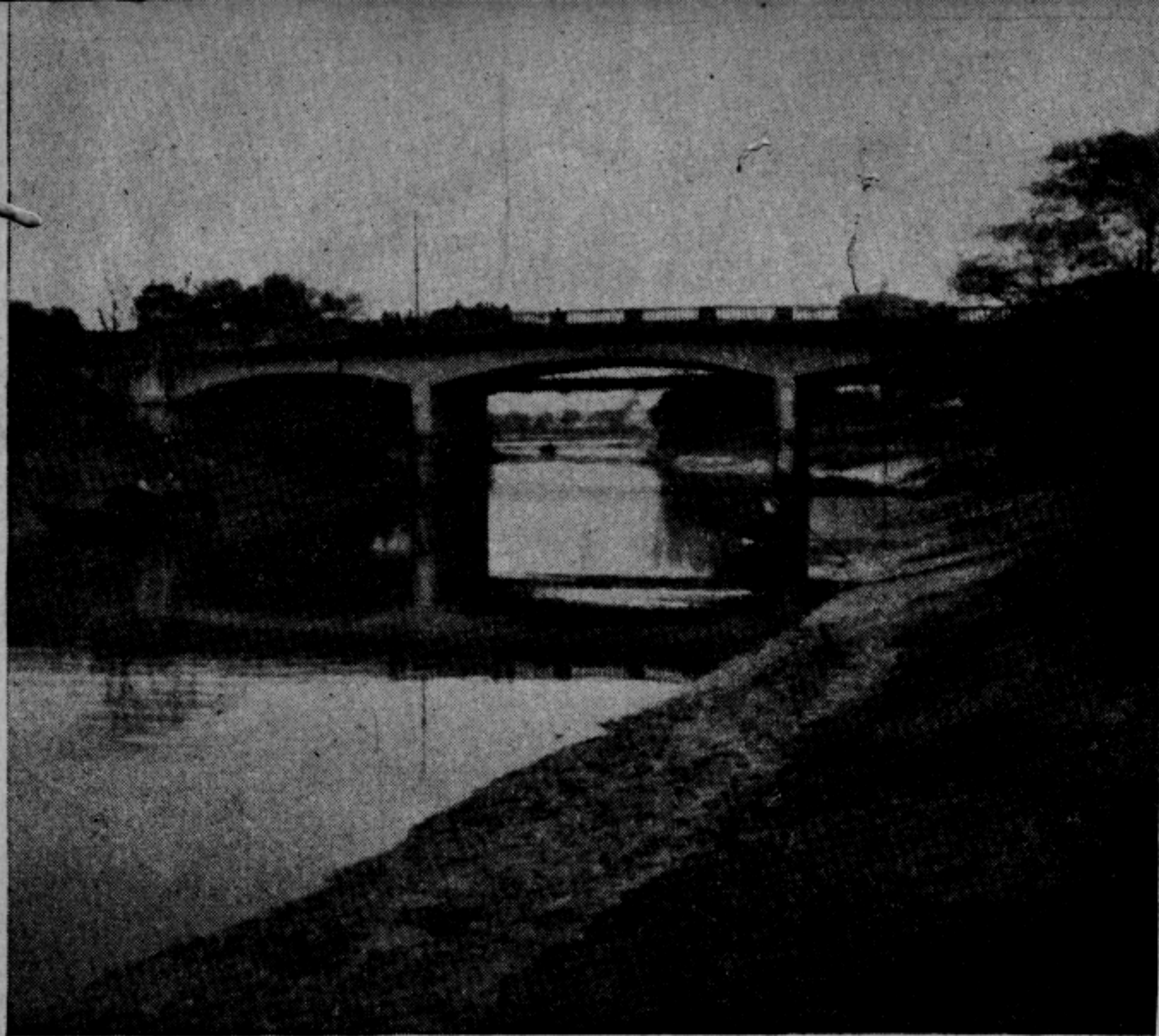


Plate 61.
Bally Khal Bridge.

Photo—Author.

C. Road Bridge across cannal

(9) *Elliot Bridge*: It is an example of N-type girder on Foreshore Road across Swarnamoyee Khal, a creek which passes through B. E. College and ultimately discharges a portion of drain water of Howrah into the river Hooghly. It is situated on the south of the existing Shalimar Railway Station. It has a clear span of 72'-0", effective span of 76'-4" and overall length of 78'-0". The depth of the girder is 8'-2" and carries a clear roadway of 16'-0". The distance between centre to centre of the girder 17'-10". The bridge was erected for the convenience of the public by Messrs Burn & Co. in 1894. "The money was donated

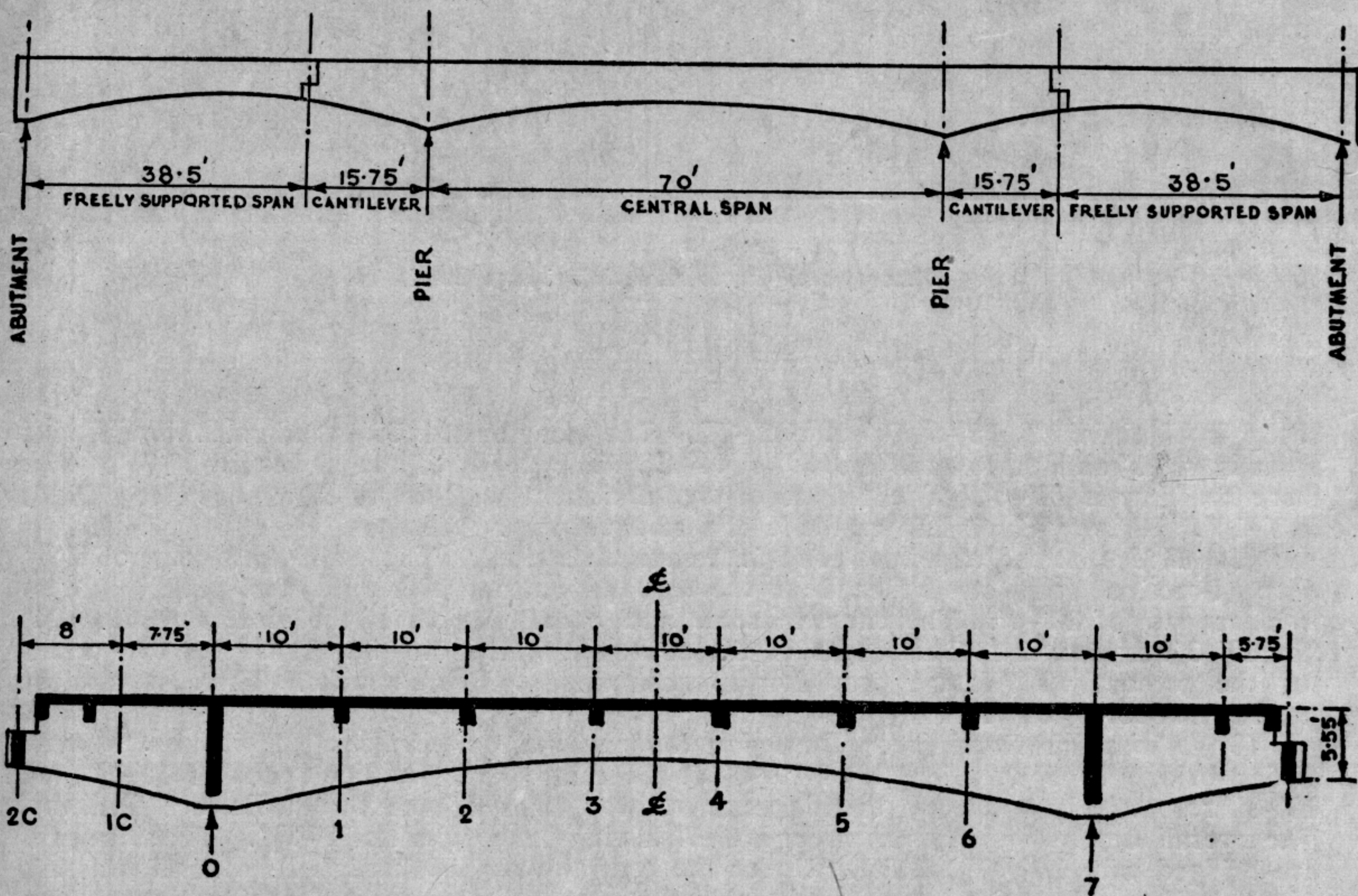


Fig. 13.
Skeleton diagram of Bally Khal Bridge.

by Sir Gopal Das Seal" for its erection. There is practically no approach inclination to this bridge.

(10) *Bridge on Jagacha Road across Drainage Canal*: There is a twin span masonry arch road bridge across Howrah Drainage Canal which is flowing along the periphery of Greater Howrah. The overall length of the bridge including two shore abutments is 44' accommodating a roadwidth of 16'. Overall clearance from the bed of the canal is 20.8 ft and that from the water level is 17.55 ft. Dwarf brick parapets have been provided along the edges of the bridge.

(11) *Bally Khal Bridge on G. T. Road*: The example of judicious distribution of shear reinforcement in reinforced concrete beam of varying thickness is wonderfully demonstrated in the Bally Khal Bridge on Grand Trunk Road. It consists of a central span of 70 ft with cantilever projections of 15.75 ft across the pier at each end. Two freely supported shore spans of 38.5 ft each are supported at the water side on the cantilever projections of the central span whereas the shore ends rest on the two abutments. The line diagram discloses the above span distribution and the relative positions of supports, i.e., piers and abutments. The effective length of the bridge is 178.5 ft. From kerb to kerb the width of the roadway is 30 ft with 9.5 ft clear footpaths at a little higher level on each side of the kerbs. The bridge deck is supported by five longitudinal curved beams of the matching profile spaced at 10.5 ft centres having a portion of the footpath carried by cantilever slab. The designed capacity of the bridge is to carry the live load of a 26-ton steam wagon followed by a lane of 12-ton lorries with a suitable impact factor. In addition to the above load for the whole bridge the footpaths have been designed for uniformly distributed live load of 100 lb/sq ft. The arrangements of R. C. cross beams are shown in the adjacent diagram at 10 ft centres for the central span. The depth of the beam of the central span varies from 9.50 ft at the support to 4.67 ft at the mid-span. The breadth of the rib is kept at 19 inches. The soffits of the beams are curved. The downward slope starts from the distance of 20' from the centre of the bridge to an inclination of one in thirty (1 : 30). There is no separate traffic lane for the isolation of slow-moving traffic from fast-moving one but as a rule bullock or buffalo carts move along a lane close to the footpaths for pedestrians.

There are many other short span stereotyped bridges, with or without ornamentation, within Bellilious Park, Botanical Garden, and over minor Khals and Nullahs which deserve no special consideration for their description and reference.

References

- | | | |
|---|-----|------------------------------|
| 1. Bridge Engineering, Vol. I and II (1916) | ... | J. A. Waddell. |
| 2. Economics of Bridge Work (1921) | ... | J. A. Waddell. |
| 3. A Practical Treatise on Suspension Bridges (1929) | ... | D. B. Steinman. |
| 4. Iron Bridge Construction (1864) Vol. I. and II | ... | W. Humber. |
| 5. A Practical Treatise on Bridge Construction (1924) | ... | Claxton Fidler. |
| 6. Economy in Bridge Design and Construction | ... | H. W. Joyce. |
| 7. Bridge Engineering (1933) | ... | Dufour and Schantz. |
| 8. Bridges (1929) | ... | C. S. Whitney. |
| 9. Design of Highway Bridges (Steel Timber and Concrete) 1920 | ... | M. S. Ketchum. |
| 10. Types and Details of Bridge Construction, Parts I, II and III (1904) | ... | F. W. Skinner. |
| 11. Movable and Long-Span Steel Bridges, 1st Edn. (1923) | ... | Hool and Kinne. |
| 12. A Text-Book on Roofs and Bridges, Part III (Bridge Design), 4th Edn. (1903) | ... | Merriman and Jacoby. |
| 13. Highway Bridge Design (1918) | ... | D. Y. Hill. |
| 14. Welded Highway Bridge Design (1952) | ... | J. G. Clark. |
| 15. Comparative Bridge Designs | ... | J. G. Clark. |
| 16. Bridges | ... | Prof. C. H. Khadilkar. |
| R. C. Bridges | | |
| 1. Reinforced Concrete Bridges (1931) | ... | W. L. Scott. |
| 2. Reinforced Concrete Bridge Design (1941) | ... | Chatto and Adams. |
| 3. Reinforced Concrete (Bridges) | ... | Taylor Thompson and Smulski. |
| 4. Reinforced Concrete Construction (Bridges) | ... | G. A. Hool. |
| 5. Design and Construction of Reinforced Concrete Bridges (1948) | ... | Legat, Dumn & Fairhurst. |